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ENVIRONMENT & ECOLOGY

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Organisms & their Environment

ECOLOGY

Ecology (Gk. oikos = home, logos = study) is the branch of biology that deals with the inter-relationships amongst organisms and interactions between organisms and their environment. The term ecology is believed to have been coined by **Ernst Haeckel** (1869) though its first authenic use was made by **Reiter** (1885).

Ecology has two main branches -

(i) **Autecology/Species Ecology.** The study of reciprocal relationships between every stage of development of a population/species and its environment is called autoecology.
(ii) **Synecology**. It is the study of reciprocal relationships between composition, organisation and development of communities and their environment.

Genecology - Study of genetic composition and changes in relation to the origin of ecads, ecotypes, new species, etc.

ECOLOGICAL HIERARCHY

The hierarchy in the levels of organisation connected with ecological grouping of organisms is called **ecological hierarchy** or **ecological level of organisation**. There are no sharp lines or breaks in the functional sense amongst various levels of ecological hierarchy as the same individual is a component of population, biological community as well as ecosystem.

Individual (Organism). It is a distinct living entity or distinct package which carries out all life processes in its body, separate from those in other individuals. An individual organism is the basic unit of **ecological hierarchy** as it continuously exchanges materials and information with its environment. New individuals develop from pre-existing ones. Hereditary characters are transferred during this process. The **constituents of an individual cannot survive independently**.

Population. It is a grouping of similar individuals in a particular geographical area or space. The different populations of the same organism present in particular geographical areas are called **local populations/demes**. A local population adapted genetically to its particular environment is called **ecotype**. There may be several ecotypes of the same organism which show variations amongst them.

Biological or Biotic Community. It is an assemblage of populations of different species of plants, animals, bacteria and fungi which live in a particular area and interact with one another through competition, predation, mutualism, etc.

Ecosystem. It is a segment of nature consisting of a biological community and its physical environment both interacting and exchanging materials as well as energy, e.g., pond ecosystem.

Landscape. It is a unit of land distinguished by a natural boundary and having patches of different ecosystems.

Biome. A large regional unit delimited by a specific climatic zone, having a particular major vegetation zone and its associated fauna, e.g., tundra desert, temperate deciduous forest, tropical rain forest, ocean.

Biosphere. It is biologically inhabited part of earth along with its physical environment consisting of lower atmosphere, land and water bodies.

The short term properties of atmosphere at a given place and time with respect to such conditions as heat, cold, sunshine, rain, cloud, wind, etc., is called weather.

Climate is the average weather conditions of a particular region of earth or area with regard to temperature, rainfall, air pressure, seasonal variations and weather extremes.

Four climate and vegetation zones have been recognised on the basis of mean temperature along the latitude.

A similar but miniature climate and vegetation zonation occurs over mountains along the increasing **altitude**. A high mountain in tropical area will have all the fours zones – tropical, subtropical, temperate and alpine (an equivalent to arctic/antarctic). A mountain in subtropical area will have only three zones (subtropical, temperate and alpine) while the one in temperate area would have only two zones (temperate and alpine).

However, variations occur in each zone due to changes in annual and seasonal precipitation. Therefore, vegetation and soil types are determined by two climatic factors, temperature and precipitation.

MICROCLIMATE (MICROENVIRONMENT)

It is the local variation of a climate that occurs in an area of limited size. Below a tree temperature is higher than the surroundings in winter while it is lower during summer. Canopy of tall trees is exposed to strong light and high temperature during the day while plants occurring below receive dim light, lower temperature and higher humidity.

HABITAT

It is a specific place/locality delimited by a combination of factors, physical features and barriers where a community resides, e.g., pond, desert, river, valley, saline soil, etc.

Microhabitat

It is a part of habitat having a specific property, e.g., forest floor, tree canopy, tree trunk, edge of a pond.

Niche/Ecological Niche (Joseph Grinnel)

It is the functional role of a species or organism in an area depending on type of food and its availability, shelter, type of predator or timing of activity. Tadpole and adult frog occupy different ecological niches as the former is herbivorous and aquatic while the latter is carnivorous amphibian. Water Bug and Water Boatman live in shallow edges of ponds but occupy different niches as the former is predator while the latter is scavenger. Both Owl and Cat feed on Shrews, and Mice. They occupy the same niche because of being **ecological equivalents** though their habitats are different.

The constituents of environment which directly or indirectly influence the form and functioning of organisms in any specific way are known as environmental factors. They are of two types – **abiotic** (physical) and **biotic**. The abiotic factors affect structure, life history, physiology and behaviour of organisms, e.g., atmosphere, air, light, temperature and precipitation, soil, topography, etc. The biotic factors mostly influence growth and reproduction, e.g., plants, animals, microbes.

ABIOTIC FACTORS

Atmosphere

Atmosphere is transparent gaseous envelope around the earth which extends upto 1600 km. It contains nitrogen (78.03%), oxygen (20.99%), noble gas argon (0.94%), carbon dioxide (0.036%) and traces of other gases with water vapours and dust particles present in the lower region.

Water vapours absorb infra-red radiations (keeping the earth warm) and maintain hydrological cycle essential for maintaining life on earth. Other components which maintain heat balance of earth are CO_2 and ozone.

Atmosphere is divisible into four parts: **troposphere**, **stratosphere**, **mesosphere** and **thermosphere**.

(i) **Troposphere.** It extends 8 – 16 km from surface of earth showing decreasing of temperature with height from 15°C to –57°C. Lapse rate or decrease in temperature is 6.4°C for 1 km. All climatic changes, cloud formation, dust particles, movement of air masses and water vapours are restricted to troposphere.

Top of troposphere which makes the transition between troposphere and stratosphere is called **tropopause.**

(ii) **Stratosphere.** It extends from 8 – 16 to 30 – 50 km. Clouds, dust particles and air masses are absent. Water vapours and CO_2 are very little.

Ozone occurs in concentration of upto 1.0 ppm, as compared to 0.05 ppm in troposphere.

Maximum ozone density is found between 15 – 30 km, at 23 – 25 km height above equator and 11 – 16 km height over poles. It is called **ozone layer** or **ozonosphere.**

Ozone layer has two variable holes, a larger over South Pole (Antarctica) and a minor over north pole.

High speed jets usually fly in stratosphere, causing depletion of ozone.

Ozone protects earth by filtering out ultra-violet radiations.

Transition between stratosphere and mesosphere is called **stratopause**.

(iii) **Mesosphere**. It is present 50 – 100 km height. Temperature decreases from –2°C to –92°C. Gas molecules become charged.

(iv) **Thermosphere**. It lies between 100–500 km height. Temperature rises from –92°C to 1200°C. Ionised layers occur which are collectively called **ionosphere**. Ionosphere protects earth from cosmic rays.

ENVIRONMENTAL FACTORS

CLIMATIC

LIGHT

Part of light which is effective in photosynthesis is called **Photosynthetically Active Radiation** (**PAR**). Its wavelength is 400 – 700 nm (0.4 – 0.7 µm).

The energy spectrum ranges from cosmic rays to radiowaves. Just before entering the mesosphere the energy content of solar radiations is **2 cal/cm^2/min**. It is called **solar constant**.

Ultraviolet rays have a wavelength of 100 nm –320 nm and (0.1 µm – 0.4 µm). They are of three types –UV-C (100 nm – 280 nm), UV-B (280–320 nm) and UV-A (320 – 390 nm). **UV-C is lethal** while UV-B is quite harmful.

Fortunately, UV-C and 50% of UV-B are absorbed by ozone layer. Rather **52%** of solar radiations are filtered out or scattered by components of atmosphere. Only **48%** reach the earth.

Effects of Light

Flowering is increased. Differentiation of various tissues and organs in response to light is called **photomorphogenesis.**

Aphids develop wings in response to alternate light and darkness.

In humans, prolonged exposure to light causes **tanning** or darkening of skin. Some animals show seasonal colour changes.

Flowers of some plants open or close in response to light and darkness. This phenomenon is called **photonasty**.

Nyctinasty is folding of leaves in response to darkness.

Planaria and **earthworm** generally show negative phototaxis.

Most animals are active during a particular period of the day – **diurnal** (during day), **nocturnal** (at night), **auroral** (at dawn), **vesperal** (at dusk) and **crepuscular** (both at dawn and dusk).

Phenology or the timing of seasonal activities of organisms (e.g., flowering, migration) is usually controlled by photoperiodism.

Bird Migration. Birds of colder areas of northern hemisphere begin their southward migration as the day lengths begin to shorten. Reverse journey is undertaken with the increase in day length.

Hibernation. In temperate and subtropical areas, cold blooded or ectothermic animals undertake hibernation as the day length begins to shorten.

Flowering. Most plants flower at a particular season in response to a particular photoperiod, e.g., spring, summer, autumn or winter.

Animal Breeding. Turkeys, Ferrets, breed in response to lengthening of of days while goat, sheep, deer breed in response to shortening of days. Rabbits and guinea Pigs are day neutral.

Light Zones in Aquatic Habitats. The is a light zonation in deep lakes and oceans.

Littoral Zone. It is shallow coastal region. Light is able to pass through water and reach the bottom. Therefore, producers occur throughout from surface to bottom.

Limnetic Zone. It is open water zone where water is very deep. Amount of oxygen and light decreases with depth. Limnetic zone is differentiated into three zones–photic, aphotic and abyssal.

Aphotic Zone. It is zone of deep water below the photic zone and above the bottom to which light does not penetrate (except some U.V. rays). The zone is, therefore, in perpetual darkness. Producers do not occur in this part. Instead only consumers are found.

Abyssal Zone. It is the bottom zone. In deep lakes and seas, the bottom is also in perpetual darkness.

TEMPERATURE

Atmospheric temperature of a place depends upon its latitude, altitude, topography, slope aspect, season, vegetation and humidity. Vertical temperature gradient over earth's surface or lapse rate is 6.4 – 6.5°C.

There is a similar lowering of mean temperature from equator to poles – tropical, subtropical, temperate and arctic.

Organisms living in these zones are respectively called **megatherms, mesotherms, microtherms** and **hekistotherms**.

Stenothermal organisms live in areas where temperature remains almost uniform throughout the year, e.g., warm tropics, sea shores

Eurythermal organisms can tolerate large scale variations in temperature. They live in areas where there are different temperatures at different times of the year.

Thermal Stratification in Lakes. Deep lakes show three temperature strata.

Epilimnion. Upper stratum of water which is exposed to solar radiations. It is warmer during summer and Effects of Light

Metalimnion. It is a transition zone between epilmnion and hypolimnion. Maximum temperature change occurs in middle part of metalimnion called **thermocline.**

Hypolimnion. It is basal stratum where water is always cool but is above freezing point, e.g., 4°C.

AIR/WIND

Lower part of atmosphere called air moves and forms wind due to uneven heating and rotation of earth. It has a direct mechanical effect and an indirect physiological effect.

Direct Effect of Wind

Leaf/Bud Damage. Leaves, branches and buds break. Sometimes, the whole plants are uprooted. The phenomenon is called **wind throw**.

Deformation. Branches do not develop to windward side. Trees appear like flag poles and are called **flag trees.**

Lodging: Herbs and shrubs bend at the base and flatten over the ground. It reduces yield.

Dwarfing: In windy areas large trees do not grow, e.g., above timber line in arctic and alpine regions.

Soil Erosion: In wind swept areas soil cover becomes dry, loose and prone to erosion. Soil becomes thin and infertile.

Physiological/Indirect Effect of Wind

Desiccation. Evaporative loss of water increases in wind. As a result plants often undergo **wilting**.

Reduced Growth. Excessive evaporation reduces water availability for growth. Therefore, organisms remain **dwarf**.

Salt Spray. Wind picks up salt rich water droplets over the sea and deposit the same over the surface of land organisms causing **exosmosis** and blocking of stomata.

WATER

Only **3%** is fresh water. **70%** water (2.1% of total) is found as ice/snow, **22.4%** (0.67%) as ground water while the remaining is present in lakes, rivers, etc.

Water evaporates from oceans, ponds, lakes, ground, plants (as transpiration) and animals (as sweat and in breath). Water vapours condense and from clouds which precipitate to produce rain and snow. 90% of ocean evaporation returns to it as rain while **10% extra falls on land surface**. This forms lakes, rivers and ground water.

At any time atmosphere contains **0.13×10^{12} G** (1G = 10^{20} g) water vapours. Annual precipitation is around 4.46×10^{20} G. This requires constant addition of water vapours and their condensation.

Hydrologic cycle has two components, **global** and **local**. Local component is also called **short cycle**. It involves evaporation of water from an area, its condensation high up in the atmosphere and precipitation over the same area.

Global component is **long cycle** that involves circulation of water vapours in the atmosphere, movement of clouds, precipitation, movement of water from one area to another. Hydrological or water cycle is energised by solar energy.

Various aquatic habitats are sea (**marine**), estuary (**estuarine**), pond, lake (**lentic**) and rivers (**lotic**).

Bottom is called **benthic** habitat while above bottom is the **pelagic** habitat.

Organisms confined to bottom are called **benthos**.

Pelagic organisms are differentiated into **plankton** (microscopic, drifting over surface), **neuston** (macroscopic, floating or swimming on or near water surface), **nekton** (actively swimming inside water), **benthic** (**benthos**) organisms are at the bottom or sea bed e.g. starfishes, snails, slugs, microorganisms, these are creeping or crawling and scavenger organisms. they are in darkness or in shallow water, some light may penetrate.

FIRE

Causes of fire may be physical (lightning, sun heating, rubbing), biological (microbial) and man-made.

Subterranean fires are flameless and are called ground fires.

Dried organic matter (leaves, branches) lying over ground produces **surface fires**.

Burning of canopy produces **crown fires**.

EDAPHIC

SOIL

It is the upper weathered humus containing part of earth's surface which can substain terrestrial plant life.

Weathering or breaking of rocks into fine powder can occur due to atmospheric changes, mechanical forces (**mechanical weathering**), chemical changes (**chemical weathering**) and biological breakdown (**biological weathering**).

The weathered mineral matter is changed to soil by the process of **pedogenesis** (pedology is science of soil) which involves **humification** (formation of humus), **evolution** (washing down or leaching) and **illuviation** (deposition in lower layers).

Residual soils develop *in situ.*

Transported soils are brought from other places through gravity (**colluvial**), running water (deposited at flood plains and called **alluvial**), wind (**eolian** = aeolian) and glacier (**glacial soil**).

Soil Profile. It is cross-sectional appearance of morphologically and physico-chemically different layers or horizons superposed over one another. There are five horizons – O, A, B, C and D. A and B constitute **solum**.

O-Horizon. It is surface layer of organic matter which lies above the true soil. It has two parts Aoo and Ao. **Aoo** (O_1) is the upper subhorizon which consists of freshly deposited organic litter of fallen leaves, twigs, bark, animal remains and animal excretions. Ao (O_2 is lower subhorizon which contains organic matter in various stages of decomposition.

A-Horizon. It is dark coloured spongy top soil which is rich in mineral and organic matter, shows maximum biological activity and **humification**. Top soil is differentiated into A_1 of dark colour and A_2 of light colour (zone of **eluviation**).

B-Horizon. Subsoil (or horizon of **illuviation**) with dark colouration in B_1 and light colour in B_2. It is mainly mineral zone. **Leaching** of minerals occur from A horizon.

C-Horizon. Rich in moisture with irregular rock fragments or sedimentary deposits.

D/R-Horizons. Bed rock.

Soil Types

Red Soils. Most famous are acidic **laterite soils** which are deficient in lime, magnesium, phosphorus and potassium but are rich in organic matter, iron and aluminium. It is suitable for the cultivation of tea, coffee, rubber, cardamon, areca-nut and paddy.

Black Soils. Also called **black cotton soils/(=regurs)** They are in dark brown or black colour due to organic matter, clay/hydrated iron and aluminium silicates and undifferentiated B-horizon.

Alluvial Soils. Soils which are transported by mainly river water.

Terai/Babar Soils. Mostly **colluvial**, (transported by gravity).

Soil Composition

Inorganic Matter/Mineral Particles – 45%. Water – 25%. Air – 25%. Humus – 5%. Living Organism – Variable. Mineral particles are of four types. **Gravel** (fine pebbles). 1 – 10 nm. **Sand** (Quartz or SiO_2). 0.02 – 1.0 mm. **Silt** (very fine quartz grains). 0.002 – 0.02 mm. **Clay** (hydrated silicates of aluminium). Less than 0.002 mm.

Clay and humus are the main determinants of soil properties.

Loam Soils. These soils contain 20% clay, 40% silt and 40% sand. They have good nutritive status, aeration and hydration. Ideal for plant growth.

Soil pH. Plants grow best in neutral or slightly acidic soils. Slight alkalinity is helpful in growth of grasslands and some crop plants like legumes.

Soil Porocity : It is the percentage and type of soil pores. They are of two types.

(i) **Macropores.** Noncapillary pores of more than 20 µm diameter. Water percolation (**gravitational flow**) occurs through macropores of 50µm.

(ii) **Micropores.** Capillary pores with diameter of 20 µm or less. Hold water by **capillarity**. Present 30% in good soils.

Humus : It is partially decomposed and partially synthesized dark amorphous mater. It contains humic or phenolic complexes, soluble proteins, soluble sugars, aminoacids and organic acids.

Formation of humus is called humification.

Humus has a high water holding capacity and makes the soil aerated.

Soil Water

Precipitation/irrigation is the source of soil water.

Form of soil water

Hygroscopic water: Thin layer of water attached tightly to soil particles due to forces of cohesion or adhesion. This is non-available to plants

Gravitational water: This is a part of water which goes into deep soil horizons due to force of gravity. This is non-available to plants.

Capillary water: Inter-particle spaces act as minute capillaries and some amount of water is present in these capillaries due to surface tension. This water is called capillary water. This is available to plant.

Combined water: Some amount of water which is present as hydroxide of iron, aluminium silicon is called combined water. It is non-available to plants.

Water vapours: Some part of water is present in the form of vapours.

Holard: Total amount of water present in the soil.

Chresard: Water available to plants.

Echard: Water non-available to plants.

Field capacity: Amount of water present in the soil after complete drainage of gravitational water is called field capacity.

Field capacity = Holard – Gravitational water.

Water holding capacity = Field capacity – Hygroscopic water.

Permanent Wilting Pwercentage (PWP):

Percentage of water left in soil when plants growing in it show signs of permanent wilting.

Soil moisture is expressed in terms of pF. In fully saturated soils pF = 0

At PWP, pF = 4.2

Tensiometer: Amount of water in soils is measured with this

BIOTIC FACTORS (Shelford 1911)

(A) Range of Tolerance

A factor that limits growth, development, reproduction or activity of an organism by its deficiency or excess is called **limiting factor**.

According to **law of tolerance (Shelford**, 1911**)** the abundance and distribution of organisms is controlled by their **limits of tolerance (critical minimum** and **critical maximum)** to ecological factors.

Range of tolerance is the range between critical minimum and critical maximum limits of environmental factor/factors influencing an organism.

The response of an organism to the range of an environmental factor (e.g., sunlight, temperature, nutrient) shows a **bell-shaped curve**. In the central optimum part of the range is the **optimum zone of tolerance** which favours maximum fitness, growth, abundance and survival. The sides have **zones of stress**. Fewer individuals occur and survive in the zones of stress (limits of tolerance towards minimum and maximum of the factor/factors). They are not able to reproduce. The areas where ecological factor occurs below its critical minimum or above its critical maximum are called **zones of intolerance** or **lethal zones**. Organisms do not occur in the zones of intolerance.

Range of tolerance for all the factors influencing a species is also known as **ecological amplitude.** It has an optimum area of range below and above which physiological stresses occur that culminate in the limits of tolerance.

Organisms with wide range of tolerance are called **eurytopic** while the ones with narrow range of tolerance are called **stenotopic.**

Acclimitisation : It is the development of a favourable morphological and physiological response to a change in environment.

Most of the acclimatisation changes are biochemically based.

(B) Ecological Adaptations

These are special characteristics evolved by organisms in order to line under a prevailing set of environmental conditions.

Ecotypes and Phenotypic Plasticity. Phenotype or physical expression is a product of interaction of expression of a genotype of an organism in a particular environment.

Variations produced amongst individuals of a species due to influence of local conditions of a habitat are collectively called **phenotypic plasticity**. It results in the formation of ecotypes.

Ecotypes are local populations of a species which are genetically adapted to a particular variations of environment. They differ in morphological and physiological characters. Although ecotypes of a species differ genetically, the differences are only minor so that they are interfertile.

The transition area between two ecotypes shows a gradual change from one ecotype to other largely due to interbreeding. This is called '**ecocline**'.

(C) Plant Adaptations

These are plants of dry habitats where the environment favours higher rate of transpiration than rate of absorption.

Plant adaptations to light Regime: Sun and shade plants.

Sun plants (=heliophytes) : Plants growing in bright light.

Shade plants (=sciophytes) : Plants growing in partial shade or low intensity light.

In a forest, plants get arranged in various strata according to their shade tolerance. This phenomenon is called stratification.

Types of Xerophytes

Ephemerals or **Drought Escapers**. The plants live for a brief period during the rains. The rest of the year is passed in the form of seeds, e.g., *Euphorbia prostrata, Tribulus terrestris, Boerhaavia.*

Annual or **Drought Evaders.** The plants live for a few months even after the stoppage of rains. For this they have modifications to reduce transpiration e.g., *Echinops echinatus, Solanum surattense.*

Succulents or **Drought Resistants.** The plants have fleshy organs where water and mucilage are stored. Depending upon the organ where succulence occurs, the succulents show **chylophylly** (fleshy leaves, e.g., *Aloe, Agave*), **chylorhizy** (fleshy roots, e.g., *Asparagus*) and **chylocauly** (fleshy stems, e.g., *Opuntia, Euphorbia, Asparagus*).

The chylocaulous forms have leaf scales or leaf spines with green, photosynthetic stems called phylloclades (stems of indefinite growth) and cladodes (1-2 internode long stems)

Succulents perform crassulacean acid metabolism (CAM).

Non-succulent Perennial Xerophytes or Drought Endurers. They are true xerophytes which actually tolerate drought conditions. They have smaller shoot system. The root system is very extensive. It may spread along the soil surface in order to absorb every drop of rain as well as dew. In a type of xerophytes called **phreatophytes** the roots are very deep. They reach the water table. Phreatophytes are, generally, used to locate ground water, e.g., *Tamarix, Prosopis.* Leaves or leaflets are often small, vertical, thick and leathery. They have either reflecting surfaces, (e.g, *Nerium*) or possess a coating of hair (e.g. *Gnaphalium, Aerua*). In grasses, the leaves roll up during dry weather to reduce surface exposed for transpiration. In *Capparis decidua* the leaves are small and drought deciduous. In *Casruarina* the leaves are vestigial. Lamina vestigial while petiole enlarges to form phyllode in Australian species of

Acacia. Leaves may possess prickles and spines. The plants contain anthocyanins, resins, gums, latex, proline (an amino acid) and chaperonins.

Proline is useful in maintaining osmotic and water potential.

Chaperonins are heat shock proteins which protect other proteins from denaturisation at high temperature.

Cuticle is thick with wax coating.

Stomata are sunken and restricted to lower surface of the leaves. Palisade parenchyma is more developed.

Spongy parenchyma is absent or reduced.

Bark is thick and develops very early.

Grasses of hot and arid regions perform. C_4 photosynthesis.

PLANT ADAPTATIONS TO AQUATIC ENVIRONMENT

HYDROPHYTES

Roots of Hydrophytes are poorly developed/completely absent in *Wolffia*, *Ceratophyllum* etc. roots are poorly branched (e.g., *Pistia*); root hair absent or poorly developed (except in those which grow in mud), *Lemna minor* lacks root hairs. Root caps absent but **root pockets** may be present (e.g. *Eichhornia*, *Pistia*, *Trapa*).

Stem in Hydrophytes

Reduced in free floating plants (e.g., *Pistia*).

Narrow and slender in submerged, suspended plants (e.g., *Hydrilla, Ceratophyllum*).

Well developed in attached plants; rhizome growing through the mud (e.g., *Nymohaea, Typha*).

Leaves in Hydrophytes

Usually long ribbon like (e.g., *Potamogeton*) or finely divided (e.g., *Ranunculus*) or thin membranous (e.g., *Hydrilla*) – lesser resistance to water currents.

Heterophily. In some hydrophytes, leaves of different forms are produced by same plant; aerial leaves are not dissected but submerged ones are dissected (e.g. *Ranunculus aquatilis, Limnophyla*).

Petioles become long, swollen and spongy for floating and keeping lamina afloat on the water surface (e.g., *Nymphaea, Nelumbo, Saggitaria*).

Anatomical adaptations of hydrophytes

Absence of cuticle over epidermis in submerged parts.

Stomata absent (or functionless) in epidermis of submerged plants/plant parts but in plants with floating leaves (e.g. *Nymphaea*), stomata present only on the upper surface which is covered with waxy cuticle.

Aerenchyma well developed; helps in buoyancy and gaseous exchange.

Epidermal cells contain chloroplasts for maximum capturing of diffused light.

Mechanical tissues like sclerenchyma/collenchyma are poorly developed/absent. However, sclerenchymatous sclereids may be present to provide strength.

Vascular tissues poorly developed. In some plants, xylem is represented by only some tracheids. Sieve tubes are smaller.

Secondary growth is absent.

Vegetative propagation is common–by **runners** (e.g., *Marsilea*), **offsets** (e.g., *Pistia, Eichhornia*), **rhizomes** (e.g., *Typha*).

Absorption of salts and water through entire surface; osmotic potential of cells is equal to or is slightly higher than external water; some amounts of CO_2 and O_2 is liberated during respiration and photosynthesis and is stored in air chambers for use in photosynthesis and respiration, respectively.

Types of hydrophytes

Free floating e.g. *Wolffia, Lemna, Spirodella, Pistia, Eichhornia, Azolla, Salvinia.*

Submerged

(i) **Suspended** e.g. *Utricularia, Hydrilla, Ceratophyllum, Najas.*

(ii) **Rooted** e.g., *Vallisneria, Elodea, Isoetes, Potamogeton.*

Emergent or **rooted floating** (fixed at the bottom of water body by well developed roots but leaves/shoot are partly/completely aerial).

With floating leaves e.g. *Nymphaea, Nelumbo, Trapa, Victoria, Nymphioides.*

With erect shoots (amphibious or marshy plants : grow in shallow water along the margin of pond/lake e.g. *Ranunculus, Sagittaria, Monochoria, Typha, Marsilea, Cyperus.*

Interesting points of some hydrophytes

Eichhornia (water hyacinth)–spongy and swollen petiole, water weed, originally belongs to America.

Lemna (Duck weed)–thaloid plant body, 1–2 balancing roots.

Wolffia - rootless and smallest angiosperm.

HALOPHYTES

Plant adaptations to saline environment.

Halophytes are special types of xerophytic plants which grow in saline soils, mangroves, coastal dunes and tidal marshes with high concentrations of salts like NaCl, $MgCl_2$, $MgSO_4$ (hence **physiologically dry soil**).

Halophytes show characteristics of xerophytes. Eg. : *Sueda, Salicornia, Tamarix, Atriplex* etc.

Many halophytes actually secrete salt through chalk or salt glands. Eg.: *Atriplex, spartina*, etc.

Thick cuticle, sunken stomata, anthocyanin and tannins occur to reduce insolation and prevent desiccation.

Halophytic communities growing on swamps are called **helophilous** halophytes. Helophilous communities are of two types : (i) **Salt swamp** and **salt desert,** (ii) **Littoral swamp forest**.

Littoral swamp forests are most extensive, occur in all tropical seas particularly on flat, muddy shores. It is flooded with water either permanently or at high tide. Such swamp forests from a characteristic vegetation – **mangroves** e.g. *Sonneratia, Rhizophora, Avecennia.*

Mangrove plants possess small negatively geotropic vertical roots called pneumatophores for gaseous exchange.

They show vivipary (seed germination while attached to plants)

PLANT ADAPTATIONS TO OLIGOTROPHIC SOILS :

Oligotiopic soils which are poor in nutrients are found in tropical rain forests. Despite growing in oligotropic soil, nutrient accumulation is high in vegetation. Most of the nutrients (84%) undergo biogeochemical circulation.

The major adaptation of tropical plants is the presence of mycorrhizae.

Mycorrhiza : A mutatistic association of plants roots with fungi.

Helps in absorption of critical elements from organic compounds (Phosphorous)

Help in absorption of water.

Protects from soil borne pathogenic fungi. It is of 2 types

(a) **Endomycorrhiza :** Fungus sends hyphal ends into cortical cells as vesicles and arbuscules.

(so called vesicular - arbuscular mycorrhiza - VAM)

Eg. : tropical trees, orchids, grasses etc.

(b) **Ectomycorrhiza :** Fungus forms a mantle on outside and inter cellular hyphae in cortex of roots. Host secretes nutrients in intercellular spaces. Eg. : pine, oak, *Eucalyptus*.

ADAPTATIONS IN ANIMALS

Animals adapt themselves to

(a) Particular feeding habit (carnivory and herbivory)

(b) Protection from predators.

(c) Changing colour for easy predation.

(d) Structural and behavioural adaptation to attract male

(e) Physiological and behavioural adaptation to environmental changes and stress conditions.

Migration: It is a two-way movement of an animal group to other places for food, climate and other reasons.

Migration is of three types–**daily, seasonal, cyclic**. The distance may be short or long. The longest distance travelled by an animal is that of sea bird Arctic Tern (*Sterna parasissaea*).

Periodic migration occurs in locusts when their number increases beyond the feeding capacity of the homeland. Large populations migrate in search of food to various directions.

Camouflage (Cryptic Appearance). It is the ability to blend with the surroundings or background. It is the most common type of adaptation by animals to remain unnoticed for protection or aggression, e.g., insects, reptiles and mammals.

Mimicry. It is resemblance of one species with another in order to obtain advantage, especially, against predation. The species which is imitated is called **model** while the animal which imitates is known as **mimic** or **mimictic**. Model is either ferocious or distasteful to predator.

Mimicry is of two types, **Batesian** and **Mullerian**.

Batesian Mimicry. The mimic is defenseless. It has, however resemblance to a dangerous or unpalatable model so that the predator usually does not prey upon it, e.g., Viceroy Butterfly mimics unpalatable toxic Monarch Butterfly.

Mullerian Mimicry. It is resemblance to two animal species, especially insects, both unpalatable/ferocious, to their mutual benefit, e.g., Monarch Butterfly and Queen Butterfly.

Warning Colouration. Dart frogs (*Phyllobates bicolar*, *Dendrobates pumilio*) found in tropical rain forests of South America are highly poisonous as well as brightly coloured to be easily noticed. Predators usually avoid them.

Echolation. Bats are nocturnal flying mammals which do not employ eyesight for location of their path, food, place of rest, etc. They produce high frequency sound which produces echoes after striking various objects on the principle of sonar. Echoes are analysed by the bats to know their path.

Hibernation and Aestivation. Hibernation or **winter sleep** and aestivation or **summer sleep** are quite common in ectothermal (cold blooded) animals. They, however, also occur in those warm blooded or endothermal animals which do not migrate from area of intense cold or heat. Frog, an ectothermal animal, shows both hibernation and aestivation.

Adaptations to Excessive Cold. (Cold Hardening). Sea animals cannot undergo hibernation. Sessile animals cannot migrate. These and some other animals protect themselves from excessive cold by developing cold hardiness, e.g., barnacles and molluscs of intertidal zones of cold areas, several **insects and spiders**. Cold hardiness is achieved by developing extra solutes in the body fluids and special ice nucleating proteins in the extracellular spaces. These extra solutes which prevent freezing are glycerol and antifreeze proteins. They lower the freezing point of body fluids. Ice Fish (*Chaenocephalus*) or Antarctic Fish (*Trematomus*) remains active even in extremely cold sea water due to this hardiness.

Adaptation to Water Scarcity. Animals facing water scarcity as found in arid or desert areas, show two types of adaptations—reducing water loss and ability to tolerate arid conditions—Kangroo/Desert Rat seldom drinks water. It has a thick coat to minimize evaporative desiccation. The animal seldom comes out of its comparatively humid and cool burrow during the day time. 90% of its water requirement is met from metabolic water (water produced by respiratory breakdown) while 10% is got from food. Loss of water is minimized by producing nearly solid urine and faeces-Camel has a number of adjustments to desert conditions – economical in water consumption, minimizing surface exposure, tolerance to fluctuations of temperature, no sweating till body temperature rises to 55°–66°C, maintenance of blood stream moisture with body cells capable of tolerating upto 40% dehydration. The animal produces dry faeces and concentrated urine. During period of nonavailability of water the animal stores urea and does not produce urine. When water is available, camel can rehydrate itself quickly by drinking large quantity of water, some 80 litres in 10 minutes.

Ecological Interdependence and Interactions

Species interdependence : Members of biotic community depend upon one another for food, reproduction, dispersal and protection.

Food : Each biotic community has a specific trophic structure consisting of food chains and food webs in which plants, animals and microbes are involved.

Zoophile : Pollination by animals mainly by insects.

Zoochory : Fruits & seeds dispersal by animals especially by birds and mammals. In many cases plants provide food to animals for this job.

Nest parasites : Cuckoo lays eggs in the nests of crow for incubation and raring of young ones.

Gall wasps : They lay eggs deeper in tissues of leaves and young stems for protection, hatching and feeding.

Camouflage & Mimicry : Camouflage is resembling surroundings for avoiding detection by prey/predator.

Mimicry resembling other organism.

Scavenging (Feeding on dead bodies) : Such animals which feed on dead bodies are called scavengers. Scavenging keep earth clean.

Eg.: Vulture, crow, ant etc.

INTERACTIONS IN BIOTIC COMMUNITY

Interaction	Species A	Species B
Mutalism	+	+
Protoccoperation	+	+
Commensalism	+	zero
Parasitism	+	–
Predation	+	–
Competition	–	–

Commensalism

One is benefitted without the other being harmed. It is of two types, periodic contact and continous contact.

Clone Fish is able to protect itself by living in the company of Sea anemones.

Pilot Fish (*Naucrates*) and Remora/Sucker Fish (*Echenies*), remain attached with Shark.

Epiphytes perch on other plants for space only, *e.g.*, many mosses, ferns and orchids.

Mutualism/Symbiosis

It is a mutually beneficial relationship/interaction between individuals of two different species.

Mutualism/symbiosis is generally considered to be **obligatory**.

The non-obligatory mutually beneficial relationship is called **protocooperation.**

Rhizobium (nitrogen fixation) and roots (shelter, food) in nodulated legumes.

Trichonympha (cellulose digesting flagellate) in intestine of termite.

Protocooperation

It is a non-obligatory beneficial relationship that develops when two different organisms get associated with each other.

Ox Pecker *(Buphagus* species) on skin parasites of Rhino.

Crocodile Bird *(Pluvianis)* rids Crocodile of leeches sticking inside its mouth

Shrimp eats up the parasites on the body of Fish.

Amensalism

Without deriving much benefit, one inhibits the other by secreting **allochemics**. The phenomenon is called **antibiosis**.

Smoother crops do not allow weeds to grow, e.g., Sorghum, Sunflower, Barely,

Sacred Basil *(Ocimum sanctum,* vern, Tulsi) does not allow weeds to flourish nearby.

Convolvulus arvenis inhibits germination of wheat seeds.

Silver Oak (*Grevillea robusta)* shows **autopathy** as it does not allow its own seeds to germinate.

Competition

It is rivalry for obtaining the same resource. Competition is of two types, intraspecific and interspecific.

(i) Intraspecific Competition

It is a competition amongst members of same species for common resource.

Intraspecific competition is for food, space and mate.

Cannibalism (eating members of the same species) reduces this competition (e.g., snakes, scorpions)

(ii) Interspecific Competition

It is rivalry amongst members of different species.

Every type of organism has a particular **niche.** No two types of organisms can have the same niche. One of the two is eliminated. The phenomenon is called **Gause hypothesis** or **principle of competitive exclusion.**

Another mode or reducing competition is **mimicry** or resemblance/imitation of an organisms to another organism or inanimate object in order to confuse its prey/predator.

Parasitism

This is an interaction between two organisms in which one (called parasite) derives synthesized food from another living organism (called host).

Besides food, parasites also obtain shelter from their host.

They have different types of adaptations to reach their hosts, live in contact with them and obtain their requirements. Such types are called parasitic adaptations.

There are six categories of parasites.

Ectoparasites : Live outside host body.

Eg : in animals - sucking lice, fleas, ticks etc.

in plants - Eg.: aphids

on living tissue - Eg.: scabmites

on dead tissue - Eg.: biting lice

Endoparasites : Live inside the host body.

Intracellular - Eg.: Malarial parasite *plasmodium vivax*

Tissue parasites - Eg.: *Trichinella*

Body fluid parasites - Eg.: *Trypanosoma* etc.

Gut or cavity parasites - Eg.: *Ascaris, Taenia* etc.

Temporary parasites : Live in contact with host for only a part of their life or occassionally at the time of feeding. Eg.: Female mosquito, bed bug, leech etc.

Permanent parasites : Live in contact with host throughout their life. They are transferred to new host as egg, cyst or directly.

Eg.: *Ascaris, Entamoeba,* etc.

Holoparasites : Are completely dependent on the host for all their requirements.

Eg.: *Rafflesia, Cuscuta* etc.

Hemiparasites : Receive only a part of nourishment from the host while the rest is manufactured by them.

Eg. : *Viscum*

Stem and root parasites : They are parasitic on plants and are in contact with the host plant either in the region of stem (lac insects, aphids) or root (root nematodes).

Total stem parasites - Eg.: *Cuscuta*

Partial stem parasites - Eg.: *Viscum, Loranthus, Cassytha* etc.

Total root parasites - Eg.: *Rafflesia, Orabanche, Balanophora* etc.

Partial root parasites - Eg.: *Santalumalbum, Striga* etc.

Pathogenic : Parasites causing diseases in the host.

Eg.: **Bacteria** *Corynebacterium diphtheriae* - diphtheria

Mycobacterium leprae - leprosy

Rusts, smuts, and powdery mildews of plants, fungal diseases, ringworm etc.

Non-pathogenic : May not harm the host

Eg.: *Entamoeba coli*.

Hyper parasite : Paraite living on another parasite.

Eg.: Bacteriophages - bacterial viruses

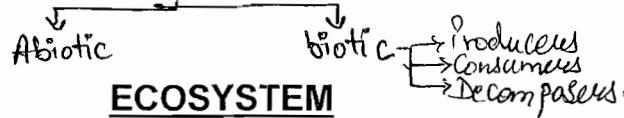
Cicinnobolus cesatic - on powdery mildew.

Predation

Predation is a mechanism of biology control that helps in keeping the population of various organisms under check.

One organism called **predator** captures, kills and eats another organisms called **prey**.

Carnivorous plants are also predators, *e.g. Nepenthes, Drosera, Ultricularia.*

A predator can become pray for another.

A rise in predator population with reduced prey population, which in turn will cause reduction in the population of predators due to starvation and emigration.

A rise in harbivore population will result in overgrazing, shortage of herbage ultimately reduction in herbivore population.

Negative human interactions

- Primitive shifting agriculture (jhoom)
- Hunting, over grazing
- Scraping and litter removal.
- Introduction of weeds and deforestation.

Ecosystem

Abiotic — biotic → Producers, Consumers, Decomposers.

ECOSYSTEM

Ecosystem is known by different terms, i.e., biogeocoenosis or geobiocoenosis or microcosm or ecosom or Holocene or biosystem or bioinert body, etc., the whole earth can be called biosphere or ecosphere.

Ecosystem is self regulatory.

Term ecosystem was first of all given by **A.G.Tansley** (1935).

According to Odum an ecosystem is the basic fundamental unit of ecology which includes both the organisms and the non-living environment each influencing the properties of the other and each is necessary for the maintenance of life.

TYPES OF ECOSYSTEM

It is mainly of two types:

(A) Natural Ecosystems

(1) Terrestrial natural ecosystem :e.g., forest ecosystem, grassland ecosystem and desert ecosystem, etc.

(2) Aquatic natural ecosystem : It is further of two types

(i) Fresh water ecosystem :

(a) Lentic (stationary water) : e.g., pond ecosystem, pool ecosystem, ditch ecosystem.

(b) Lotic (running water) : e.g., river ecosystem, stream ecosystem, spring ecosystem.

Study of fresh water ecosystems is called limnology.

(ii) Marine ecosystem : e.g., ocean (deep water), sea (shallow water).

(B) Artificial Ecosystems or Man engineered ecosystems :

Which are governed by man, e.g., crop land ecosystems, aquarium, etc.

Structure of ecosystem

Mainly two types of components constitute the structure of ecosystem :

(A) Abiotic components or Non living components :-

These include inorganic substances or minerals , organic substances and different climatic conditions like rainfall, temperature, pH, light, etc.

(B) Biotic components or Living components :

(i) Autotrophs or Producers : Which have capacity to manufacture their own food or which can fix radiant energy of sun into chemical energy, e.g., green plants and photosynthetic bacteria.

(ii) Heterotrophs or Consumers : Which are unable to manufacture their own food and depend upon other producers or green plants for their food.

a) **Primary consumers or Herbivores or Consumers of first order:** These depend upon producers or green plants for their food.

b) **Secondary consumers or Primary carnivores or Consumers of second order :** These live upon herbivores.

c) **Tertiary consumers or Top carnivores :** Which live upon secondary consumers.

(iii)Decomposers : These decompose dead organic substances of producers and consumers into simple substances e.g. bacteria, fungi, actinomycetes, etc.

Production → performed by producers. Involves the fixation of CO_2.
a) Primary Productivity
→ related to producers.
→ photosynthesis occurs.
→ net fixation of CO_2 by producers
→ 2 types →
i) Gross Primary Productivity (GPP) → means total photosynthesis / total CO_2 fixation by autotrophs
GPP is not present in producers.

...orld. In India forests occupy only 22.8% of land area.

...inerals, organic substances, inorganic substances, climatic ...ature, etc.

...trees of the forest and shrubs as well as ground flora.

...ers : Ants, bugs, leaf hoppers, birds, some large animals like ...ng foxes, fruit bats, elephants, etc.

...mers : Snakes, lizard mongoose, some birds, etc.

...ers : Lions, tigers, etc.

...ia, fungi, actinomycetes, etc.

...sms obtain their food. Each trophic level has a specific mode ...hic Level or T_1. The trophic level consists of producers . (ii) ... consists of herbivores which feed on plants. (iii) **T_3 or Third** ... primary carnivores. (iv) **T_4 or Fourth Trophic Level.** It ... (v) **T_5 or Fifth Trophic Level.** The trophic level contains tertiary carnivores. (vi). **T_6 or Sixth Trophic Level.** In terrestrial ecosystems, it is occupied by decomposers.

FOOD CHAIN

Sequence of trophic levels through which food travels while passing from producers to ultimate consumers is called food chain.

Grazing (i) **Predator Food Chain.** It is common food chain where producers are eaten by herbivores, herbivores by carnivores and the latter by higher order carnivores.

Q. Why max diversity is present in coral reefs?
Ans → high prodn.

(ii) **Parasitic Food Chain**. It terminates at the level of parasites, e.g., Grass Cattle *Pneumococcus*. Parasitic food chain is also called **subsidiary** or **accessory food chain**.

(iii) **Saprotrophic Food Chain (Detritus Food Chain)**. It proceeds from dead bodies and organic remains.

Predator or Grazing Food Chain

It is the common type of food chain which is composed of producers and consumers.

Pond Food Chains

Phytoplankton Zooplankton Small Crustaceans Water Insects Small Fish Large Fish Birds

Oceanic Food Chains

Angiospermic plants do not occur in oceans (exception *Zostera*). Sea weeds and other algae are abundant. In open sea, phytoplankton is more abundant.

Phytoplankton Zooplankton Crustaceans Small Fish Large Fish Shark

Terrestrial Food Chains

Grass Grasshopper Frog Snake Peacock

Grass Insect Predator Insect Insectivorous Bird Hawk.

Vegetation Rabbit Fox Wolf Tiger

1. **Complete Food Chain :** It must have producers and decomposers.
2. **Size of Food Chain :** There is lesser wastage of food energy in shorter food chains.
3. **Size of Population :** Population size generally decreases with the rise in trophic level. Top carnivores are very few.

Food Web

A network of food chains which are inter connected at different trophic levels so as to form a number of feeding connections amongst members of a biotic community.

Eg.: In a grassland ecosystem.

Grass → Grasshopper → Hawk

Grass → Grasshopper →Lizard Hawk

Grass → Rabbit → Hawk

Grass → Mouse → Hawk

Grass → Mouse → Snake Hawk

Significance of food web : Food webs are very important in maintaining the stability of an ecosystem.

ECOLOGICAL PYRAMIDS (Elotonian Pyramids)

Trophic structure of ecosystem is a type of producer-consumer arrangement, in which each food level is called trophic level and the graphical representation of trophic structure of ecosystem constitutes ecological pyramids or food pyramids where **producers occupy base of the pyramid** and top consumers occupy apex of the pyramids. The concept of ecological pyramids was developed by **Elton** (1927).

(A) Pyramids of number

These may be upright, inverted or intermediate type, e.g., in grassland ecosystem, the pyramid of number is upright because number of producers (grasses) is maximum and the number goes on decreasing with every trophic level, i.e., top consumers are minimum in number.

Similarly, the pyramid of number in pond ecosystem is also upright. In forest ecosystem the pyramid of number is **intermediate** (fusiform). Here the number of primary consumers is more than producers as well as top consumers.

(B) Pyramids of biomass

These are more fundamental and may be upright or inverted, e.g., in grassland ecosystem, upright pyramid of biomass is present because biomass of producers is maximum and of top consumers is minimum. Similarly in forest ecosystem upright pyramid of biomass is present whereas in pond ecosystem these are of inverted type as biomass of producers is minimum and of top consumers is maximum.

(C) Pyramids of energy

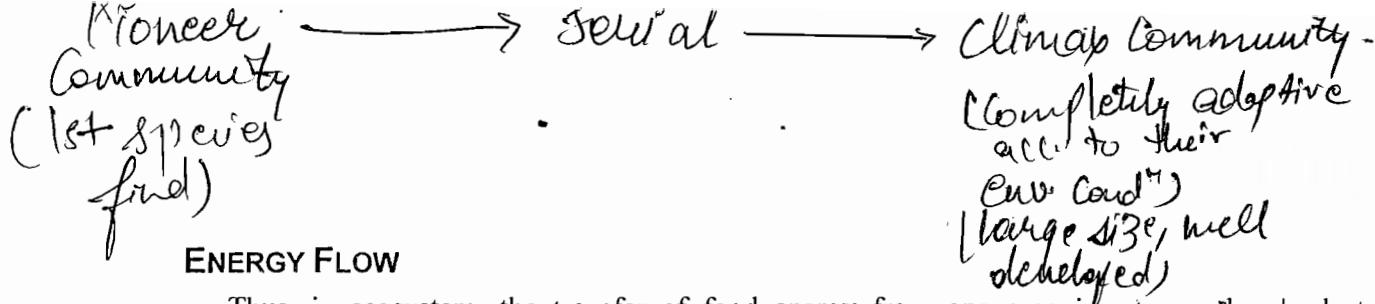
These are most fundamental and they indicate overall nature of ecosystem. Pyramid of energy is always upright in all types of ecosystem as energy goes on decreasing with each and every trophic level.

PRODUCTIVITY

The rate of biomass production is called productivity. Productivity is a rate function, and is expressed in terms of dry matter produced or energy captured per unit area of land, per unit time. It is generally expressed in terms of g m^{-2} $year^{-1}$, or kcal m^{-2} $year^{-1}$. The rate of total capture of energy, or the rate of total production of organic material (biomass), is known as **gross primary productivity (GPP).** The balance energy or biomass remaining after meeting the cost of respiration of producers, is called **net primary productivity (NPP)**.

Net primary production = gross primary production – respiration

$Pn = Pg - R$

$Pg = Pn + R$

where Pg = Gross primary production

Pn = Net Primary production

R = respiration

At the trophic level of consumers, the rate at which food energy is assimilated is called **secondary productivity**.

High level of net primary productivity (>20t ha^{-1} $year^{-1}$) has been recorded for mature tropical rain forests. Desert generally falls in the lowest productivity category (<1 t ha^{-1} $year^{-1}$).

Pioneer Community (1st species find) → Serial → Climax Community - (Completely adaptive acc. to their env. cond.) (large size, well developed)

ENERGY FLOW

Thus, in ecosystem, the transfer of food energy from one organism to another leads to degradation and loss of a major fraction of food energy as heat due to metabolic activities, with only a small fraction being stored in living tissues or biomass.

Table : Geographical Area, Mean Biomass and Net Productivity in Major World Ecosystems is shown in the table

Ecosystems	Area (10^6 km^2)	Mean plant biomass (t ha^{-1})	Mean net primary productivity (t ha^{-1} year^{-1})
Tropical rain forest	17	440	20
Tropical deciduous forest	8	360	15
Temperature deciduous forest	7	300	12
Temperate coniferous forest	12	200	8
Savanna	15	40	9
Temperate grassland	9	20	5
Desert shrub	18	10	0.7

In ecosystem, the transfer of food energy from one organism to another leads to degradation and loss of a major fraction of food energy as heat due to metabolic activities, with only a small fraction being stored in living tissues or biomass. Only the visible light, or the **photosynthetically active radiation (PAR)**, which carries about 50 percent of the energy of total incident solar radiation, is available to producers for absorption. Under favourable environmental conditions, only about 1-5 percent energy of incident radiation, or 2-10 percent of PAR, is actually captured by the photosynthetic process (gross primary productivity), and the remaining portion is dissipated, the net capture of energy (net primary productivity) is reduced to only 0.8-4 per cent of the of PAR.

FOREST BIOMES

Major forest biomes in India are :

(i) Tropical rain forest biome ;

(ii) Tropical deciduous forest biome;

(iii) Temperate broad-leaf forest biome; and

(iv) Temperate needle-leaf or coniferous forest biome

In India, the temperate forests occur.

Tropical Rain Forests

Distributed mainly along Western Ghats and in North-eastern Himalayas. *Dipterocarpus* and *Hopea* are the most common tree species, show 30-40m tall canopy structure with 4-5 strata formed by different plant species. Many tree species show buttresses (swollen stem bases).

Succession → Primary (no living org.) → Secondary (takes place in previous successive area) is a dynamic process in which change in environment

Woody climbers and epiphytes grow profusely. The soil of rain forest is highly leached and has low base content.

Tropical Deciduous Forests

The tropical deciduous forests occur widely in the northern and southern parts of our country in plain and low hilly areas. Sal (*Shorea robusta*) and teak (*Tectona grandis*) are the dominant tree species. Other useful species are tendu (*Diospyros melanoxylon*), chiraunji (*Buchanania lanzan*), khair (*Acacia catechu*). These forests are of short stature (10-20 m height). The deciduous forest soil is richer in nutrients due to lesser leaching.

Temperate Board-leaf Forests

Temperate broad-leaf forests mainly occur between 1500 and 2400 m altitude in the western Himalayas. Several species of oak (*Quercus*) predominate. These include banj oak (*Quercus leucotrichophora*), khrsu oak (*Q. semecarpifolia*), tilonaj oak (Q. *floribunda*) and rianj oak (Q. *lanuginose*). These four strata forests have 25-30 m height. The oak forests are often rich in epiphytic flora.

Temperate Needle-leaf or Coniferous Forests

In the Himalayas, the temperate needle-leaf coniferous forests are distributed over 1700 to 3000 m altitude, like the pine (*Pinus wallichiana*), deodar (*Cedrus deodara*), cypress (*Cupressus torulosa*), spruce (*Picea smithiana*) and silver fir (*Abies pindrow*). Coniferous forests are taller (30-35m) and possess evergreen canopy of long needle-like leaves.

Grassland and Savanna Biomes

Grassland : Grassland ecosystems have treeless herbaceous plant cover, dominated by a wide variety of grass species (family, Poaceae). Amongst the best known grassland biomes are the extensive "Prairle" in the north America and "Steppe" in Russia. Most remarkable aspect of grassland structure is its extensive root system.

Savanna: Commonly the term **savanna** implies a well developed grass cover, interspersed with scattered shrubs or small trees. Most abundant grasses in Indian savannas are *Dichanthium, Sehima, Phragmites, Saccharum, Cenchrus, Imperata* and *Lasiurus*. Some common trees and shrubs in *Prospis, Zizyphus, Capparis, Acacia, Butea*, etc.

Desert Biome

Deserts have been variously classified as true deserts, having less than 120 mm annual rainfall, or **extreme desert** showing less than 70 mm yr^{-1} rainfall. On the basis of temperature, deserts are distinguished into **hot** and **cold**.

The most important deserts are - Sahara of North Africa, Thar of West Asia, and Gobi of Asia.

Desert plants show phenomenon of Allelopathy i.e., they secrete some chemical substances which inhibit the growth of plants growing in their near vicinity.

Deserts show poor biodiversity and their productivity is minimum.

Process of succession → Migration.

I. Terrestrial Biomes

1. **Tundra :** It lies north of timberline or 60^0N latitude below the polar ice. Tundra occupies some 8 million km^2 area of land mass extending across N. America, Europe and Asia.

   Physical Characteristics. The area receives very little precipitation, around 25cm per year, mostly in the form of snow. The area is covered by snow for most part of the year. Ponds, pools, marshes and bogs are formed during summer.

   Flora. Vegetation is thin, North tundra is often called **arctic desert** because it contains very sparse low growing vegetation devoid of any tree. They are shallow rooted as the subsoil is permanently frozen. Mosses and lichens show best development in the area. The common moss is *Sphagnum* (Bog Moss) and the most common lichen is *Cladonia* (Reindeer Moss). Other plants growinng in tundra are grasses, sedges, heaths, a few shrubs, dwarf willows (*Salix* species) and dwarf birches (*Betula* species). The plants possess xerophytic characters.

   Fauna : Common animals of tundra are warm blooded and have protective covering like feathers (birds) and hairy skins (mammals). Main birds of tundra are snow owl and snow grouse.

2. **Taiga (North Coniferous Forest)** This biome occurs just south of tundra across north America, Europe and Asia. It is also found in the southern hemisphere (e.g., parts of New Zealand).

   Physical Characteristics. Precipitation is highly variable, 10-35 cm in drier parts and over 100cm in wetter parts. The marshes and bogs have cotton grass and *Sphagnum*. Summers are pleasant with long hours of day light and an average temperature of less than 20^0C.

   Life. Life is fairly rich in this biome.

   Flora : Dominant vegetation consists of evergreen conifers which are able to tolerate wide fluctuations of temperature, light and soil. They are Pine, Fir, Hemlock, Spruce, Juniper, Yew, Larch, Deodar (=Cedar). The ground flora consists of herbs, ferns, mosses and lichens. The latter three also occur on trees and shrubs under humid conditions. Birch and Maple are found at several places.

   Fauna. Animal community of the biome is represented by mouse, wolves, otters, beavers, elk, deer, raven, rabbit, hare, squirrels, pumas, lynx, grouse, jay, many species of insects etc. The area also receives reindeer and caribou from tundra during winter.

3. **Temperate Deciduous Forest.**

   Location. It is found in both the northern hemisphere (Canada, eastern U.S.A., north central Europe, eastern Asia) and southern hemisphere (New Zealand, eastern Australia).

   Physical Characteristics. The areas have warm summers and moderately cold winters. Annual precipitation lies between 75-150 cm.

Flora : The dominant climax vegetation consists of board-leaved hardwood (dicot) trees like Oak, Elm, Maple, Birch, Beech, Hickory, Magnolias, Poplars, etc. Shrubs are also abundant. The trees and shrubs usually shed their leaves with the onset of autumn (hence also called fall). New leaves are produced in early spring. A few soft-wood trees (conifers) may occur at places interspersed with hardwood trees.

Fauna. The animal population, includes frogs, salamander, turtles, snakes, lizards, rabbits, hares, squirrels, opossums, foxes, racoons, deer, bear, thrushes, owls, sparrows and several song birds. In winter, some animals undergo hibernation or migrate to warmer areas.

4. Tropical Rain Forest (Tropical Evergreen Forests).

Physical Characteristics : The biome occurs in equatorial or sub-equatorial regions where both rainfall and warmth are abundant. Rainfall is above 140 cm/yr usually between 200-500 cm/yr. It may be upto 1000cm. Rain occurs through major parts of the year. Therefore, humidity is good. Plant growth is luxuriant. The forest is thick and almost impenetrable. As a result it is called **jungle**. The forests occupy about **one-twelfth** of the total land but possess more than half of the flora and fauna of the world. Diversity of life is so high that a hectare of the forest may have as many as 200 speices of trees, 70-80% of all insects and 80-85% of all birds are known from tropical forests.

Productivity of the biome is very high (12000 kcal/m^2/yr as compared to 3000 kcal/m^2/yr for temperate deciduous, 2000 kcal for taiga and only 200 kcal/m^2/yr for tundra.

Flora : The vegetation shows **stratification.** Stratification is the grouping of plants in a forest into two or more well defined layers depending upon their height like tall trees. There are a minimum of five storeys or strata or vegetation. The upper storey is occupied by very tall emergent trees (50 m or more). The second storey is constituted by tall trees (35-40m) which form a dense and closed canopy.

The important plants of tropical rain forest are Rosewood, Mahogany, Ebony, Rubber tree, *Artocarpus*, Nutmeg, Cinnamon, some palms and bamboos. variations of tropical rain forest are **semi-evergreen** and **deciduous tropical forests.** The variations are produced by human interference, less rainfall, presence of dry season and shedding of leaves by some or most of the trees, e.g., *Dalbergia, Bombax, Butea, Shorea*, etc.

Fauna. Each storey or stratum has different fauna. Upper storeys have birds, insects, bats, monkeys, lemurs, tree frogs, lizards and anteaters. Ground fauna includes many snakes, some lizards, deer, forest goat, antelope, tapir, elephant, leopard, jaguar, etc.

5. Chaparral Location (Mediterranean Scrub Forest).

The biome occurs in mediterranean are (hence mediterranean scrub forest), pacific coast of North America, Chile, South Africa and South Australia.

Physical Characteristics. It is a broad-leaved evergreen scrub forest of hard and thick leaved small trees and shrubs which usually contain resin but are resistant to fires.

Life. Both plants and animals are adapted to long droughts.

Flora and Fauna. Both plants and animals are adopted to frequent and long periods of drought. The common plants of chapparal are *Arctostaphylos* (Manzita), Sage, *Carnithus, Adenostema*, (cheemise), Oak and *Eucalyptus* (in Australia). Animals include rabbits, rats, chipmunks, deer, snakes, lizartds, birds, tiger, etc.

6. Tropical Savannah

Location : The savannah is found in equatorial and subtropical regions of the world especially south America, central Africa and Australia.

Physical Characteristics. It is a warm climate plain which contains coarse grasses with scattered trees and shrubs. The organisms of the biome are drought tolerant. The biome is also frequented by fires otherwise it would be replaced by woodland. Productivity is about 3000 kcal/m^2/yr.

Flora and Fauna. Tropical savannah of central Africa is believed to be cradle of human evolution. A savannah does not have much species diversity. It is known after the dominant scattered trees, e.g., *Acacia* savannah, *Phoenix* savannah, *Eucalyptus* savannah. Hoofed herbivorous animals are quite common. Common animals are zebra, giraffe, antelope, gazelle, rhinoceros, goat, rabbit, mice, elephant, fox, wolf, tiger, lion etc. Kangaroo occurs in the savannah of Australia. Due to its easy accessibility the tropical savannah is ideal for hunting.

7. Grassland.

Location. A grassland possesses different types of grasses, non graminaceous herbs and a few scattered bushes or occasional trees. Depending upon the types of grasses and non-graminaceous flora. Grasslands have been differentiated into (a) **Prairies** of Canada and U.S.A (b) **Pampas** of South America (c) **Steppes** of Eurasia (d) **Tussocks** of New zealand and (e) **Velds** of South Africa. Prairies are further distinguished into long grass prairie, mixed grass prairie and short grass prairie or plain.

8. Desert.

Location. Deserts are found all over the world–in areas bordering cold oceanic currents, lacking cloud intercepting mountains, lying far away from cloud seeding regions or rain shadow. Major deserts occur in Asia (Tibet, Gobi, Thar and West Asia), Central Western Australia, North Africa (Sahara), South-Western U.S.A., Mexico, coastal areas of Chile and Peru.

Physical Characteristics. Hot deserts have high evaporation rate, sand dunes, sand storms or rocky areas. Nights are cold but days are very hot with temperature reaching 50^0 - 60^0C. Whatever rainfall occurs, the same passes down into deeper strata.

Flora and Fauna. Ephemeral or short-lived plants . A few plants live for 2-6 months because they are able to cut down water loss e.g., hardy grasses, *Echinops, Solanum surattense*. Succulents survive desert conditions by storing water and opening their stomata only during night, e.g., cacti, euphorbias. Example of desert animals include ants, locusts, wasps, scorpions, spiders, lizards, rattles snakes, insectivorous birds like swifts and swallows, seed eating quails, doves, desert rats, hares, foxes, jackals and cats. In camel the feet are spreading and insulated. Another exceptional mammal of the desert is Desert or Kangaroo Rat.

II. Aquatic Biomes

Aquatic biomes are of four types-

(i) oceanic,

(ii) lakes and ponds,

(iii) marshes,

(iv) streams-rivers.

1. Oceanic Biome (Marine Biome)

It has high concentration of salts with an average of 3.5%. The most abundant ions are sodium and chloride. Other common minerals are sulphur, magnesium and calcium. Productivity of oceanic biome (except coastal region) is 1000kcal/m^2/yr, less than most terrestrial biomes.

Temperature of the ocean surface is about 28°C in the equatorial regions but less than 0°C near the poles. Variations in temperature are less in deeper waters. Hot and cold currents occur at places.

Vertical zones occur in ocean depending upon the availability of light for photosynthesis. The upper 200 m layer of ocean floor receives good amount of sunlight. It is called **photic** or **euphotic zone.** Some light penetrates deeper though it is insufficient for photosynthesis. Its depth is between 200-2000 m and is called **aphotic zone.**

There is perpetual darkness below 2000 m upto the ocean floor (6000-10000 m). The dark zone is known as **abyssal zone.**

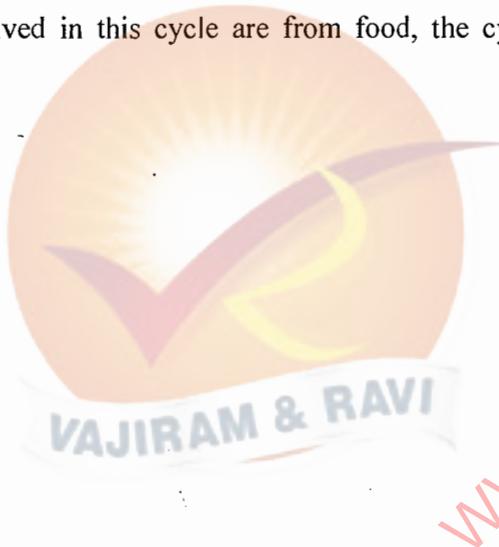
Marine life can be grouped into three main categories :

(i) **Plankton :** These are passively drifting on floating organisms. They are diatoms (phytoplankton) and crustaceans (zoo plankton)

(ii) **Nektons :** Actively moving organisms with well developed locomotory organs.

(iii) **Benthonic organisms :** These are found along the floor of the sea bed and include creeping, crawling and sessile organisms.

Other (Lakes and ponds) : These are stagnant fresh water bodies found practically in every biome.
Many lakes are direct or indirect result of glaciation.

Others are natural or man made depressions filled with water.

Eutrophic lakes (relatively shallow lakes) have a rich accumulation of organic products. Eg. : Dal lake of Kashmir.

Deep lakes with steep rocks are poor in circulating nutrients like phosphates. These are called **oligtrophic lakes.**

Some lakes contain a line or brackish water. Eg. Sambhar lake of Rajasthan.

Biogeochemical cycles : The cyclic path of the elements from the abiotic system to the biotic system and vice versa is called biogeochemical cycles.

As the chemicals involved in this cycle are from food, the cycles are also called nutrient cycles.

	Latitude	Altitude	Vegetation
1. Tundra	Above 60° North	3600 meter height of Himalaya	**Lichen, Moss, Grass** **Note :** • This biome is tree less and also known as arctic desert or alpine tundra • Timber line – Line beyond which trees are not found. • Perma frost – In this region soil is covered by snow or ice.
2. Northern coniferous or Needle leaf or temperate forest	40° – 60°	1700 to 3000 meter	**Pine (Pinus), Deodar (Cedrus), Cypress (Cupressus torulosa), Spruce (Picea smithiana), Silverfir (Abies pindrow)** **Note :** • Coniferous forest posses needle like leaves • This forest also known as Taiga
3. Temperate decidous or broad leaf forest	40° – 60°	1500 to 2400 meter	**Oak (Quercus)** **Note :** • Trees shed their leaves in autumn and bear again in spring
4. Tropical rain forest	Tropical rain forest are found at equatorial region around the earth. In India tropical rain forest are distributed mainly along western Ghats and Eastern Himalya (Assam, W. Bengal, Andman, Manipur)		**Dipterocarpus and Hopea are most common tree species in India.** **Lianas are also found.**
5. Tropical deciduous forest	Occurs widely in the Northern and Southern part of our country in in plain and low hilly area.		**Sal (Shorea robusta), Teak (Tectona grandis), Tendu, Chiraungi, Khair** **Note :** • Leaves of most of the tree fall before summer.
6. Chaparral (Mediterranean) scrub forest	These forest are found pacific coast of North America and South coast of Australia		Draught resistant and fire resistant plant species are found eg. Small tree, Shrub (sage)
7. Tropical Savanna biome (Thorn forest)	Tropical Savanna biome are found in South America and Australia.		**Coarse grass – Dichanthium, Sechima, Phragmites** **Trees – Acacia, Eucalyptus, Zizyphus, Capparis** **Note :** • In this biome grass are found with scattered tree. • This biome also known as tropical grass land
8. Grass land biome			**Name of Grass lands** → **Place** Prairies → North America Pampas → South America Steppes → Europe and Asia (Russia) Tussocks → Newzealand Veldts → Africa
9. Desert Biome			**Name of desert** – **Place/Area** Sahara – North Africa Tibbet, Gobi, Thar – Asia **Note :** • Gobi desert is cold desert • Sahara and Thar are hot desert

NUTRIENT CYCLING

bio : living organisms, and *geo*: rocks, air and water, also denote nutrient cycling. But biogeochemical cycle is generally considered in a regional or global context.

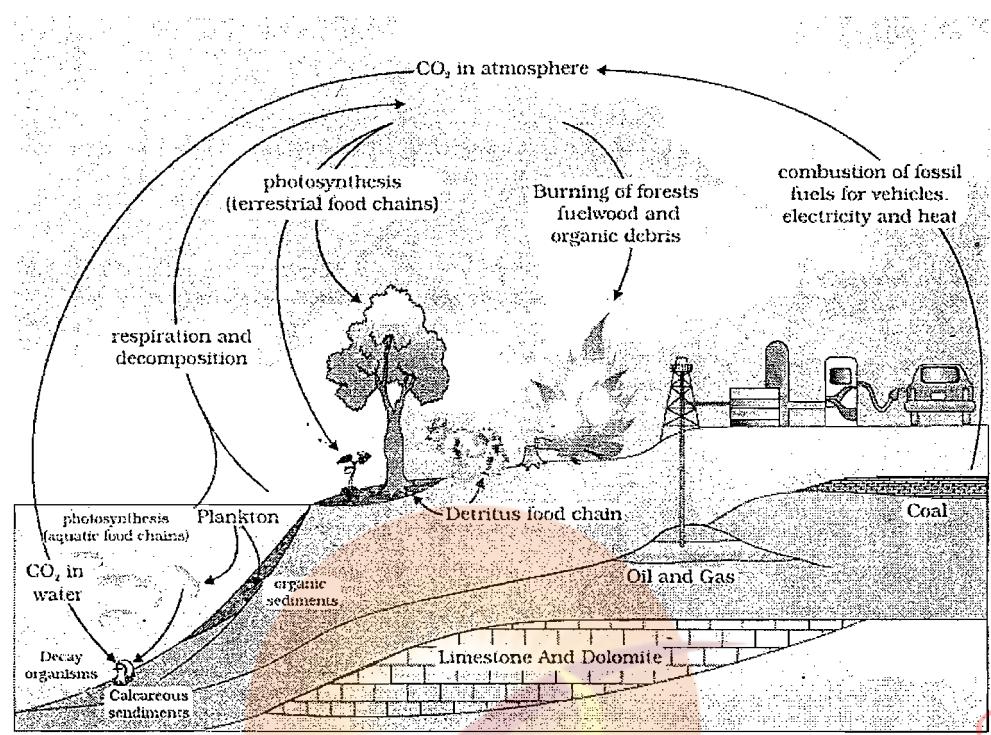



Fig.: carbon cycle in the biosphere

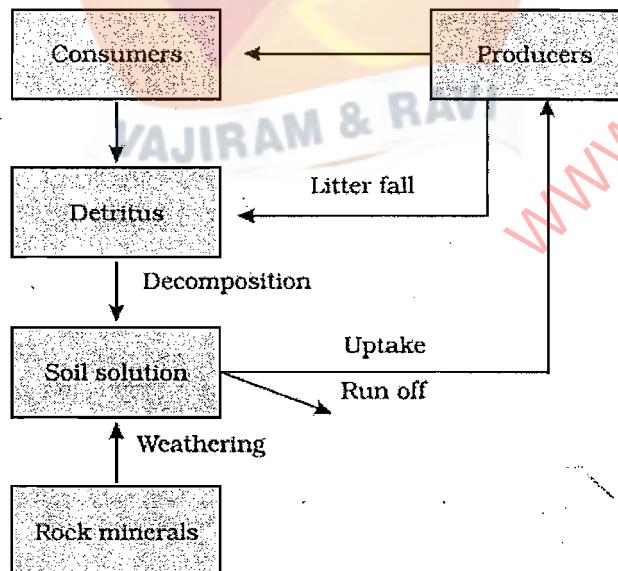



Fig.: Phosphorus cycle in a terrestrial ecosystem

Ammonification
Nitrification } Do yourself.

Plants absorbs Nitrogen mainly in the form of nitrates.

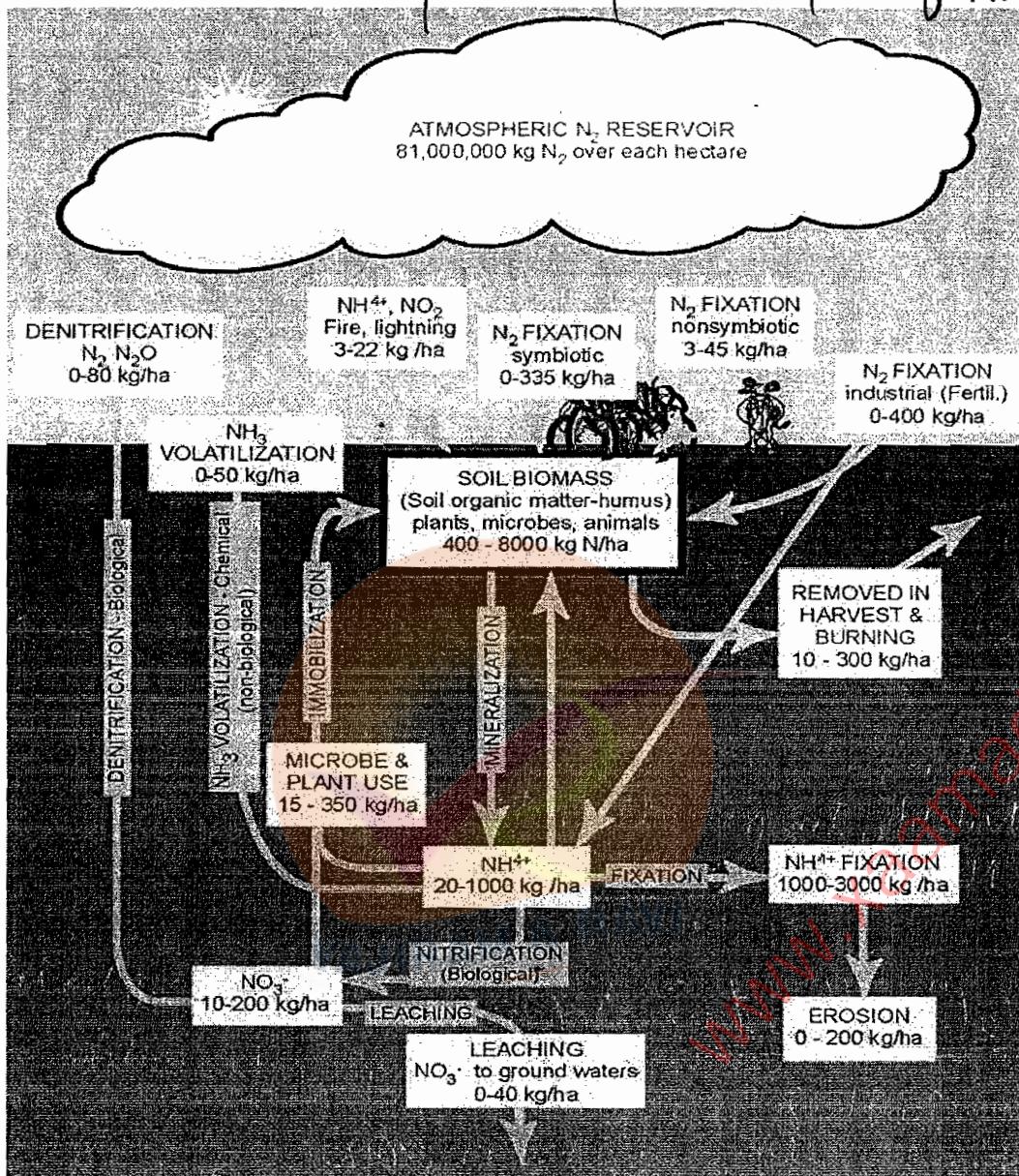
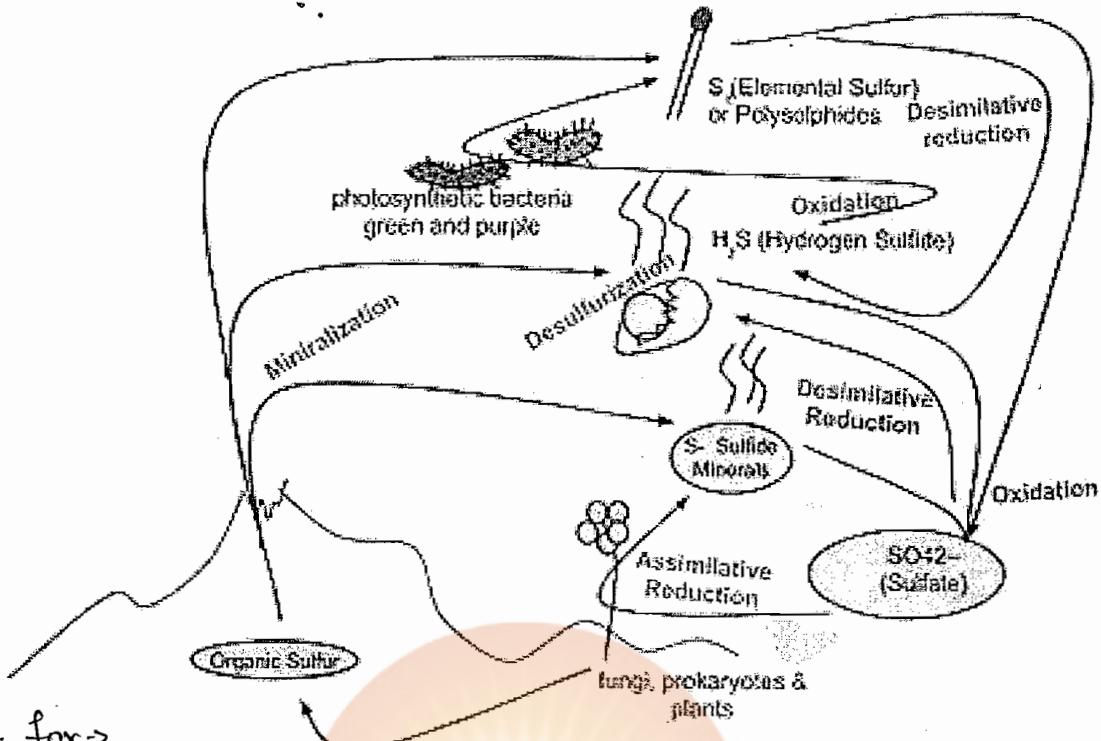



Fig.: Nitrogen Cycle

Natural
$N_2 + O_2$
↓
NO_2
+
H_2O
↓
HNO_2
or
HNO_3.

Artificial
(Industrial)
↓
Eg: Haber process in chemistry.
$N_2 + H_2 \rightarrow NH_4$.
↓
Converted to urea.
↓
used as fertilizer

Biological.
- Bacteria.
  - Symbiotic
    ↓
    legume + Rhizobium.
  - Non-symbiotic (NS)
- Blue green algae
  - Symbiotic
    ↓
    Azolla + Anabaena.
  - N[illegible]

factors resp for →

1) ↑ popl^n → Natality, Imigration (migration for resources)

2) ↓ popl^n → Mortality, Emigration.

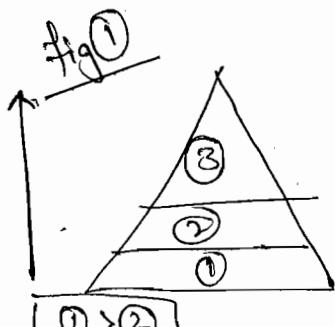



Figure: Sulphur Cycle

Populat^n attributes → 1) Natality (Birth rate) → leads to ↑ popl^n.

2) Mortality (Death rate) → " " ↓ "

3) Sex ratio

4) Age distribut^n

5) Density.

{ Immigration ↑ popl^n }
{ Emigration ↓ " }

On the basis of ecology, there are 3 types of organisms.

Pre-reproductive ① | reproductive ② | post reproductive ③

fig ①

① > ② inc. ↑ popl^n

① > ② → always max. growth of popl^n takes place.

③ > ② & ① → decrease in popl^n takes place continuously.

→ popl^n mainly depends on pre-reproductive & reproductive.

Some Important Points to Remember

Humboldt. 1° latitude or 300 ft. altitude changes temperature by 1°F

Timer Line/Tree Line. It is the zone in latitude and altitude beyond which trees cannot grow. Only shrubs **(elfin scrub)** and herbs **(alpine/arctic meadow)** occur.

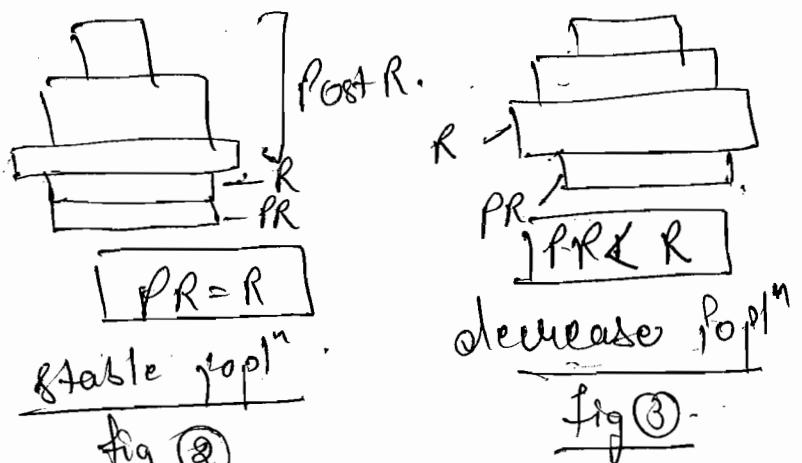
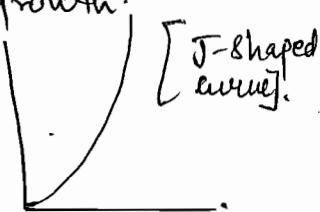
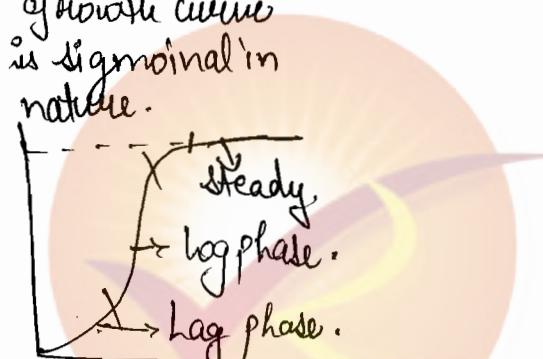
Eutrophic. Water body having good quantity of minerals and hence supra optimum growth of plants.

Oligotrophic. Water body deficient in minerals and organic growth.

Dystrophic. Rich in undecomposed organic matter. *e.g.,* bogs, marshy lakes.

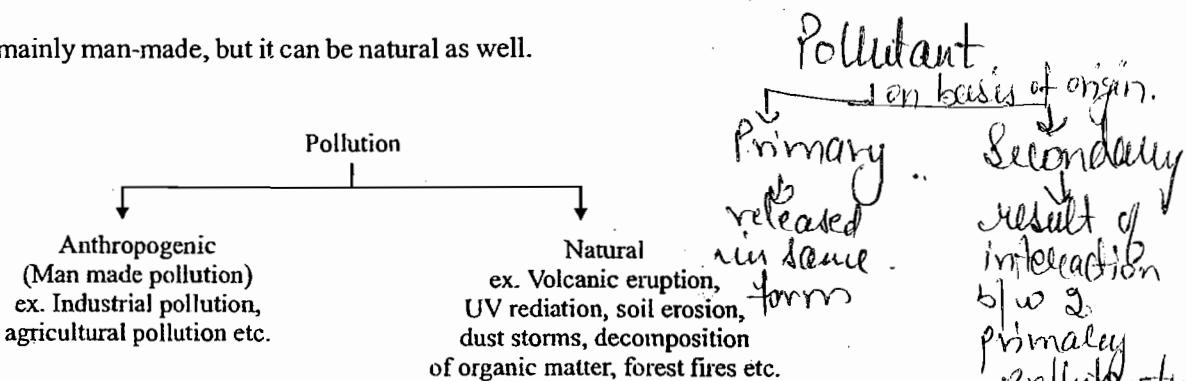
Standing Crop. Amount of living material present in an ecosystem or biome at any time. If it is measured as weight, the standing crop is called **standing biomass.**

Standing State. The amount of biogenetic/inorganic materials present in the abiotic environment per unit area at any time.

Warming (1895). Divided plants into four ecological groups–hydrophytes, xerophytes, mesophytes and halophytes.

Lentic (= Lenitic). Pertaining to standing water, swamp or lake.

Lotic Pertaining to running water, river or brook.

Heathlands. Low shrubby areas, natural or secondary, as chapparal.

Guano. Excreta from sea birds and others which can be used as fertilizer due to being rich in phosphatic and uric acid.

Carbon. It constitutes 49% of organic matter.

Exponential growth model.
↓
Occurs when resources are unlimited i.e. present in max. qty.
leads to max. growth.

[J-shaped curve].

→ no interspecific or intraspecific competition is there.
→ So, this growth depends on Biotic potential of living org.
→ Biotic potential means max. reproductive capacity. which ↑ popl^n. ↑ Biotic potential.

$$\frac{dN}{dt} = rN$$

→ N ∝ r.
↑ in no. B.P.
→ Small animals have more reproductive capacity, so more popl^n of that organism is there but their life span is less.
→ Large animals have less popl^n.

Logistic growth model:
↓
depends on carrying capacity of environment i.e. resources are limited
→ Carrying capacity can be termed as environmental stress on which popl^n of a particular species depend bcoz of limited resources.
→ growth curve is sigmoidal in nature.

Steady
log phase.
Lag phase.

→ At steady state, popl^n becomes constant i.e. no further growth takes place.

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

K → Carrying Capacity.

K↑, resources are max., popl^n growth rate ↓.

Community characteristics

1) Community structure (composition)
→ species richness
→ balance ecosystem.
→ more alternate pathways of food
→ Dominant species occurs bcoz it regulate that particular community
→ Phsiognomy (structure of community)
→ Stratification (diff. stratas are present in community).

Any undesirable change in the physical, chemical or biological characteristic of the air, water and land or soil, which is harmful to the man directly or indirectly through animals, plants, industrial units or raw materials is called pollution.

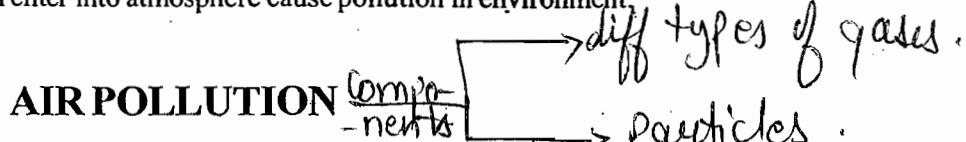
Pollution can be **positive** (presence of undesirable substances) or **negative** (absence of desirable substance).

Pollution is mainly man-made, but it can be natural as well.

Pollution

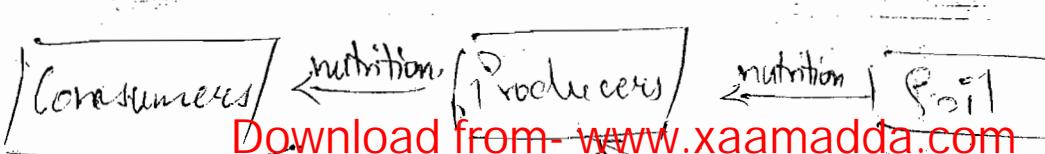
- Anthropogenic (Man made pollution) ex. Industrial pollution, agricultural pollution etc.
- Natural ex. Volcanic eruption, UV rediation, soil erosion, dust storms, decomposition of organic matter, forest fires etc.

Pollutant — on basis of origin: Primary — released in same form; Secondary — result of interaction b/w 2 primary pollutants eg → Smoke & smoke → smog + fog

The waste products of human activities are not efficiently assimilated **decomposed** or otherwise removed by natural, biological and physical processes (recycling) and the system is unable to utilise properly so that the balance of the system gets altered by the addition of such undegradable pollutants.

Pollutants : Two Types

Non-Degradable

The non-degradable pollutants such as aluminium pecks, compounds of iron, mercury, phenols or glass, D.D.T., etc. are harmful even in low concentration. These can either be banned or suitably substituted..

Bio-degradable

Those substances which are degraded completely by microorganisms are useful. But partially degraded substances, when enter into atmosphere cause pollution in environment.

AIR POLLUTION

Components → diff types of gases; → particles.

Atmosphere consists of a mixture of gases, mainly Nitrogen (79%), Oxygen (21%) and Carbon-dioxide (0.03%) mixed with water vapour and it is collectively called air.

Aerosol is a general term referring to any kind of small particles (of 1 μm) found floating in air. Particles more than (1 μm) are called **"dust"** for solids and **"mist"** for liquids.

Excessive inputs from natural and man-made sources cause serious pollution. This pollution of atmosphere can be held responsible for various health disorders and diseases and other very serious consequences like global warming, depletion of stratospheric ozone layer, acid-rain etc.

Consumers ← nutrition ← Producers ← nutrition ← Soil

Lichens and mosses can be regarded as "**indicator**" of quality and purity of air with respect to air-pollution. It is because they are very sensitive to sulphur dioxide (SO_2) and other air polluting gases. Lichens usually die and disappear when air of their environment is highly polluted.

THE MAJOR POLLUTANTS ARE :

(i) **CARBON MONOOXIDE (CO)** : It is colourless, odourless, highly toxic in nature. It combines with haemoglobin of the blood and blocks/inhibits the transport of oxygen in the blood stream. Thus, it impairs respiration and results in disorders of the cardiovascular system, headache, decreased visual perception and sometimes death due to asphyxiation when inhaled in large amount.

(ii) **SMOKE** : The smoke consists of sulphur dioxide (SO_2) sulphurtrioxide (SO_3) sulphuric acid (H_2SO_4), Ozone (O_3), Carbon dioxide (CO_2), PAN (peroxyacetyl nitrate), arsenic, fluoride, etc.

(a) **SULPHUR DIOXIDE (SO_2)** : Sulphur dioxide is next to carbon monoxide in causing air pollution. Excess exposure to this gas stings the eye and causes a burning sensation in the throat. Most important role of sulphur dioxide is in acid-rain and heavy dosage of SO_2 degrade chlorophyll and affect photorespiration in plants.

(b) **HYDROCARBONS AND NITROGEN OXIDES** : When hydrocarbons are acted upon by nitrogen oxides (especially NO_2) under the influence of ultraviolet radiations of sun-light, mixture of oxidised hydrocarbons (**peroxyacetylnitrate : PAN**) and ozone (O_3) are produced. This mixture is called "**haze**" or "**smog**".

Smog is extremely irritating to eye and throat. It is also responsible for causing diseases like asthma and bronchitis. **Peroxyacetyl nitrate (PAN)** is known to block the Hill-reaction in photosynthetic plants.

(c) **METHYL ISOCYANATE (MIC)**

METHYL ISOCYANATE (MIC) gas is used in manufacture of different carbonate pesticides. The unfortunate incidence of Bhopal in 1984 was due to this gas and from then it is known as Bhopal Gas.

Infact the Phosgene ($COCl_2$) gas is used in the manufacture process of MIC. This gas is a deadly poisonous gas and was used during world war II as a chemical weapons.

In human, MIC causes burning sensation in eyes, expels oxygen out of lungs resulting in death due to choking. The poisoning effect can be counteracted by using hydroxylamine. This chemical readily react with MIC and convert it into safer compound.

(d) **ETHYLENE** : Ethylene is an unsaturated hydrocarbon. It is released from automobile engines, combustion of natural gases, coal or wood and from incomplete combustion of almost every organic substance as well as from cigars and cigarettes which is enough to damage plants.

Excessive ethylene accelerates respiration causing premature senescence and abscission. It is very injurious to orchids and other greenhouse crops, cotton and certain other crops. In orchids ethylene causes dry sepal injury, failure of buds to open, sleepiness and the occurrence of yellow leaves. In carnation the 'sleepiness' disease involves yellowing and withering of the petals, partial opening of the buds and slow opening of the flower.

The table below gives detailed information about air pollutants, their sources and how they effect us.

Pollutant	Source	Human Health Effects
Particles (API) - Air Particle Index	• Internal combustion engines (eg, cars and trucks); • Industry (eg, factories); • Burning wood; • Cigarette smoke; and • Bushfires.	Long term exposure is linked to: • Lung Cancer; • Heart Disease; • Lung Disease; • Asthma Attacks; and • Other health problems.
Nitrogen Dioxide (NO_2)	• Motor Vehicles are the biggest contributors; • Other combustion processes;	Exposure to high levels of NO_2 may lead to: • Lung damage; or • Respiratory Disease. It has also been linked to: • Increased hospital admissions for asthma and respiratory problems; • Increased mortality.
Ozone (O_3)	Formed by various complex chemical reactions involving the exposure of the oxides of nitrogen and some hydro-carbons. Ozone is the main ingredient of photochemical smog in summer and early autumn.	Ozone effects the • lining of the lungs; • lining of the respiratory tract; and • causes eye irritation. Ozone also damages plants, buildings and other materials.
Carbon Monoxide (CO)	Motor vehicle exhaust and burning of materials such as coal, oil and wood. It is also released from industrial processes and waste incineration	When inhaled Carbon Monoxide enters the bloodstream and disrupts the supply of oxygen to the body's tissues. A range of health effects may result depending on the extent of exposure.

Point pollutants → which are released from a particular point.

Photochemical smog is pollution in congested cities.

London smog / Classical smog. → 4000 people die due to this in London in single day.

Coal (S) + smoke + fog $\xrightarrow{\text{low temp}}$ fog of H_2SO_4.

diff. b/w London & Los Angeles smog is that London smog has low temp.

Lead (Pb)	Is largely derived from the combustion of lead additives in motor fuels as well as lead smelting. Lead pollution from vehicle emissions is declining due to the introduction of unleaded fuels and reductions in lead levels in leaded fuel. Other atmospheric sources of lead include waste incineration and renovation of old houses (from leaded paint).	Lead retards learning in children and the development of their nervous system; Lead effects almost every organ in the body, whether it is inhaled or ingested. Young children are particularly susceptible;
Hydro-carbons (HC) - chemical compounds composed of Hydrogen and Carbon atoms	Most fuel combustion processes result in the release of hydro carbons to the environment. The largest fuel sources are natural gas and petrol. Note that hydrocarbons can enter the environment both as evaporative emissions from vehicle fuel systems, or in exhaust emissions. They are also a component of the smoke from wood fires.	Exposure can cause headaches or nausea, while some compounds may cause cancer. Some may also damage plants.

Smog → Photochemical smog (light energy) ⇒ produced in presence of sunlight.

Smoke + fog + NO_2 + HC + O_2 $\xrightarrow[\text{UV light}]{\text{Sunlight}}$ Photochemical smog (reddish Brown smog due to product^n of PAN & O_3)

Sideeffect of PAN → inhibits photosynthesis in plants.
↳ Animals → irritati^n in eyes & adverse effect to the lungs.

O_3 → harms to mucous membrane which is req. for moisture conditioning of our body.

O_3 in Troposphere is called bad O_3 as it causes loss to mucous membrane

O_3 in stratosphere " " good O_3, as it protects ... harmful effect of UV light

(e) Acid Rain : Presence of excessive acids in rain water is called acid rain. Any source of energy that we used either coal, fuelwood or petroleum products, has sulphur and nitrogen. These two elements when burnt in the presence of atmospheric oxygen are converted into their respective oxides, sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), which are highly soluble in water.

These oxides of sulphur and nitrogen react with large quantities of water vapour of the atmosphere during rain and form acids like sulphuric (H_2SO_4), sulphurous, nitric (HNO_3) and nitrous. These acids then return to the earth surface with rain water or may remain in the atmosphere in clouds and fogs.

Acid rain causes a number of adverse implications. It increases acidity in the soil, threatens human and aquatic life, destroys forests and crops reducing agricultural productivity.

Acid rain also corrodes buildings, monuments, statues, bridges, fences and railings.

Acid rain can play havoc with human nervous system by making the humans an easy prey to neurological diseases.

Sweden's forests have suffered a reduction in growth rates and salmon and trout fishes have disappeared from the country's streams and lakes as a result of fall in the pH caused by acid rains. Acid rains also modify rates at which nutrients are leached out from soils and foliage. The resultant acidification of the soil affects the nitrogen fixing bacteria.

There are several ways of removing particulate matter (Fig. 4.1) :

(1) **Electrostatic precipitator :** It is most widely used and can remove over 99% particulate matter present in the exhaust from a thermal power plant.

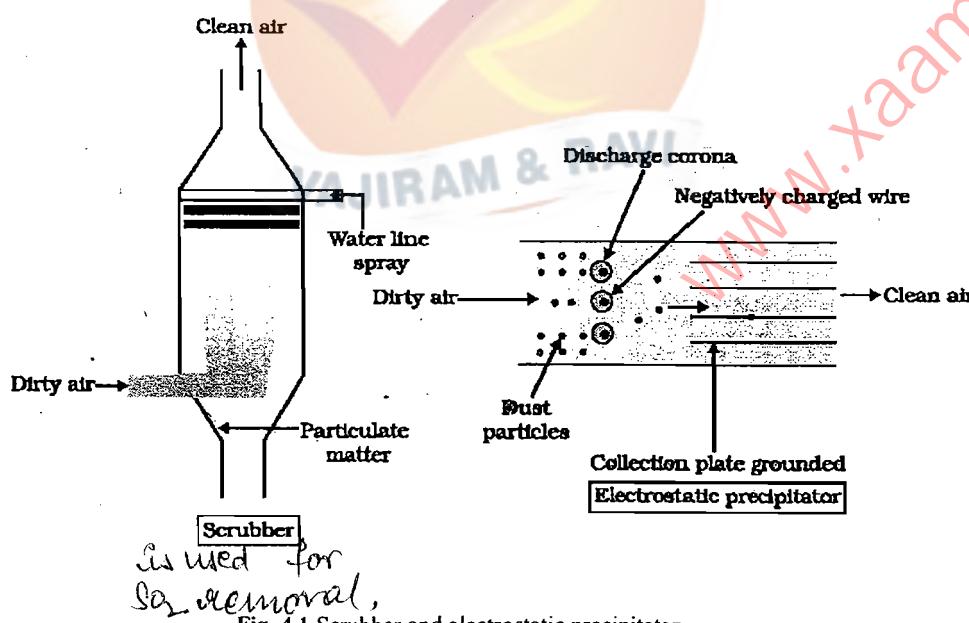



Fig. 4.1 Scrubber and electrostatic precipitator.

It has electron wires that are maintained at several thousand volts, which produce a corona that releases electrons. These electrons attach to dust particles giving them a net negative charge. The velocity of air between the plates must be low enough to allow the dust to fall.

common dust disease.

Pneumiconiosis → related to lungs.
Lungs fibrosis → cotton dust
Anthracosis → coal dust

Siderosis → Iron dust.
If particle size is ≥ 10 micron, it will be settled in one day. but particle size of ≤ 10 micron

(2) **Scrubber :** It can remove gases like SO_2. The exhaust is passed through a spray of water or lime.

According to Central Pollution Control Board (CPCB), particulate size 2.5 micrometers or less in diameter can be inhaled deep into the lungs and can cause breathing and respiratory symptoms irritation, inflammations and damage to the lungs and premature deaths.

Catalytic converters are fitted into automobiles for reducing emission of poisonous gases. It has **platinum-palladium** and **rhodium** as the catalyst. When exhaust passes through the catalytic converter, unburnt **hydrocarbons** are converted into CO_2 & H_2O and CO and nitric oxides are changed to CO_2 and N_2 gas respectively.

However, motor vehicles which are equipped with catalytic converter should use onleaded petrol because lead in the petrol inactivates the catalyst.

Controlling Vehicular Air Pollution : A case study of Delhi

All the buses of Delhi are running on **CNG** because CNG burns most efficiently and very little of it is left unburnt. It is cheaper than petrol or diesel and cannot be siphoned off by thieves and adulteruted like petrol or diesel. The only problem is to delivery of CNG and ensuring uninterrupted supply.

Major steps taken in Delhi for reducing vehicular pollution are :

(i) Phasing out of old vehicles.

(ii) Use of onleaded petrol.

(iii) Use of low sulphur petrol and diesel.

(iv) Use of catalytic converters in vehicles.

(v) Application of stringent pollution lend norms four vehicles etc.

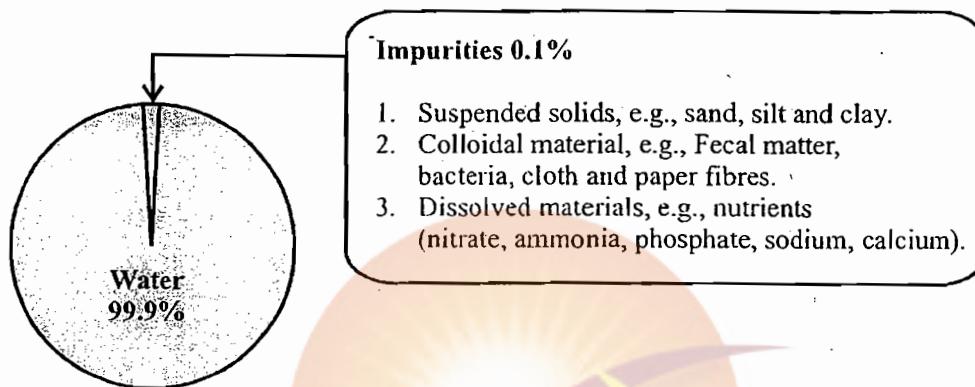
Various vehicle norms :

S.No.	Norms	**Major 11 cities of India** (Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur & Agra)	**Rest all places of the country**
1.	Bharat stage – II (Euro – II)	Applied from April 1, 2000	Applied from April 1, 2005
2.	Euro – III	Applied from April 1, 2005	Applied from April 1, 2010
3.	Euro – IV	Applied from April 1, 2010	-

Euro-II compliant vehicle require an MPF-I system (multi-point Fuel Injection System).

Euro-II norms, stipulates that sulphur be controlled at 350 ppm in diesel and 150 ppm in petrol.

Aromatic hydrocarbons are to be contained at 42%. The goal of new auto fuel policy is to reduce sulphur to 50 ppm in petrol and diesel and bring down the level to 35%.

FRESH WATER POLLUTION

Of the total fresh water stock, ground water consists of 14.1%, glaciers contain 84.56%, lakes contain 0.98%, soil moisture contains 0.299%, atmospheric vapour 0.049, and rivers contain only 0.004%.

The saturation level of "dissolved oxygen (DO)" in fresh, clean water is 14-15 ppm at 0°C. This level reduces with the rise in temperature and reaches zero ppm at 1000°C. However, the dissolved oxygen content in fresh water at normal temperature is 7.8 ppm.

The other pollutants found in water are : (i) domestic sewage, (ii) surface run-off, (iii) industrial discharges, (iv) radio-active wastes, (v) oil, and (vi) chlorinated hydrocarbons.

Domestic Sewage

Only 0.5% impurities make domestic sewage unfit for human use.

Domestic sewage primarily contains biodegradable organic matter. The amount of organic matter in sewage water can be estimated by measuring BOD.

Microorganisms involved in biodegradation of organic matter consume a lot of oxygen which causes mortality of fish and other aquatic organisms (Fig.4.2).

Fish kill and disappearance of clean water | Reappearance of clean water organisms

CONCENTRATION | Dissolve oxygen | BOD | Direction of flow | Sewage discharge

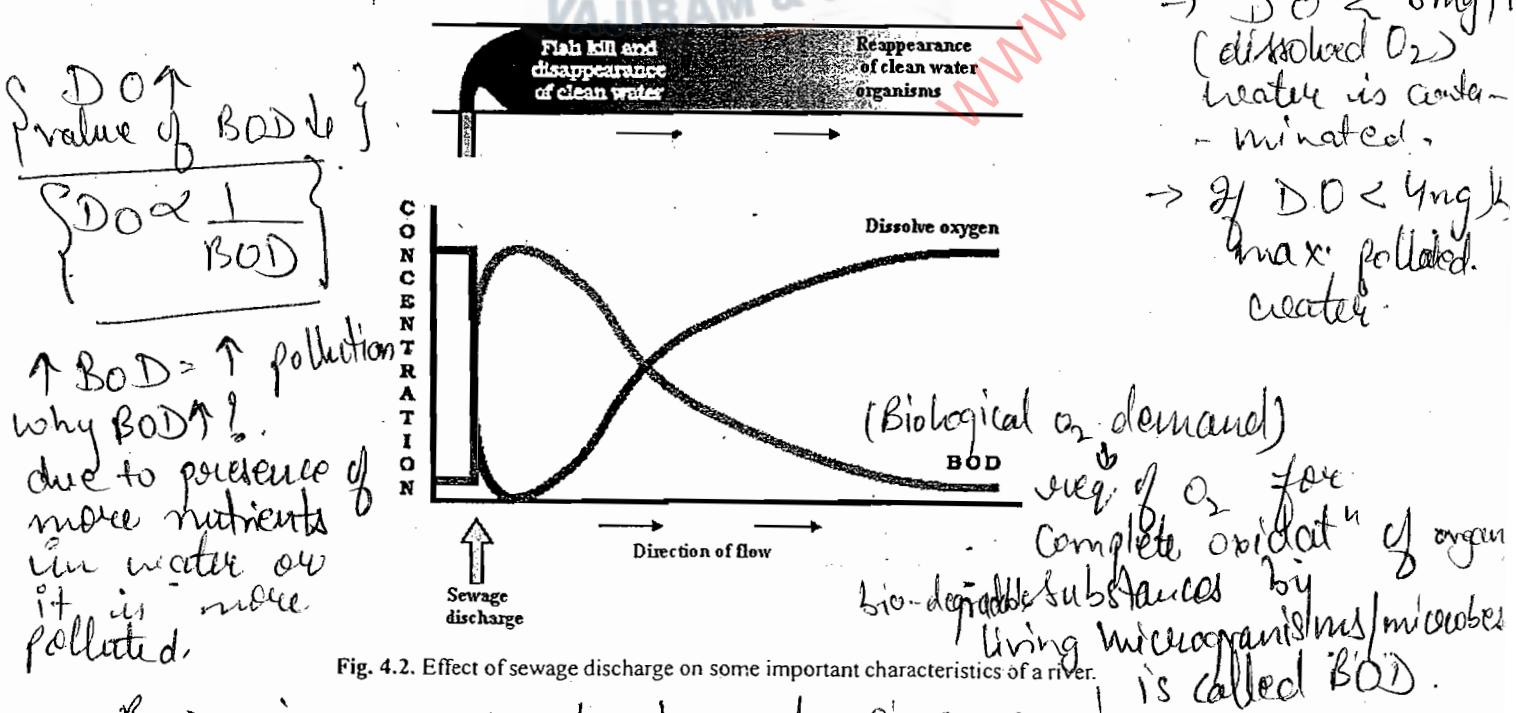



Fig. 4.2. Effect of sewage discharge on some important characteristics of a river.

BOD represents the amount of dissolved oxygen (DO) needed by the microorganisms in a particular amount of water at 20°C in five days. Higher the BOD, lower would be the dissolved oxygen DO .

Whenever the sources of freshwater get polluted by heavy loads of organic matter (especially sewage), there is a good growth of microorganism therein. These microorganisms utilize the dissolved oxygen (7-8 ppm at normal temperature) of fresh water to meet out their oxygen demand. This results in a drop in oxygen level in water. When the amount of dissolved oxygen drops below 3 ppm due to the said BOD, the fish either leave such water or die, anaerobic condition is attained and hydrolysis, putrefaction and fermentation by the microorganisms follows with the result that the body of the water becomes malodorous and cloud and hence unsuited even for recreational use and other purposes. Sewage-polluted water generally contains certain disease causing microorganisms. Following are some important waterborne disease and their causal organisms :

Typhoid fever	*Salmonella typhi*
Paratyphoid fever	*Salmonella paratyphosa*
	S. shottmuelleri, *S. typhimurium*
Cholera	*Vibrio comma*, *V. cholerae*
Bacillary dysentery	*Shigella dysentri.*
Amoebic dysentery	*Entamoeba hystolytica*
Poliomyelitis	Polio *virus*
Viral hepatitis	Hepatitis *virus*
Infectious jaundice	*Leptospira interrogans*

COD is the measure of oxygen equivalent to the requirement to oxidising organic matter content by a strong chemical oxidising agent. Dichromate is such a strong agent for most kinds of organic matter found in water.

BIOMAGNIFICATION : It refers to increase in concentration of the toxicant at successive trophic levels. A toxic substance accumulated by an organism cannot be metabolised or excreted and thus passed on to the next higher trophic level. Ex. **mercury & DDT.** Accumulation (Fig.4.3).

High concentration of DDT disturb calcium metabolism in birds, which causes thinning of eggshell and their premature breaking which resulted in the decline in bird populations.

Fish-eating birds (DDT [illegible])
Large fish (DDT 2 ppm)
Small fish (DDT 0.5 ppm)
Zooplankton (DDT 0.04 ppm)
Water (DDT 0.003 ppb)

Fig. 4.3. Biomagnification of DDT in an aquatic food chain

EUTROPHICATION : It is the natural aging of a lake by biological enrichment of its water.

Presence of large amount of nutrients especially nitrogen and phosphorus induce abundant growth of planktonic algae (algal bloom). Algal blooms cause deterioration of the water quality and fish mortality. Noxims weed water hyacinth (***Eichhornia crassipies***) also grow abundantly in eutrophic water bodies. Water hyacinth is also known as **Terror of Bengal**.

The acceleration aging of water bodies due to pollutants from anthropogenic activities like effluents from the industries and hence is known as **cultural** or **accelerated** eutrophication.

A CASE STUDY OF INTEGRATED WASTE WATER TREATMENT

The township people of Arcata (which is situated along the northern coast of California) with the collaboration of biologists from the Humboldt State University created an integrated waste water treatment process within a natural system. The cleaning occurs in two stages :

(a) Conventional sedimentation, filtering and chlorine treatment.

(b) Series of six connected marshes over 60 hectares of marsh level. (Appropriate plants, algae, fungi and bacteria were seeded into this area, which neutralise absorb and assimilate the pollutants. The marshes also constitute a century.

METAL POLLUTION

In natural water bodies, there are a variety of sources of input of heavy metal (whose density is 5 or more) and non-heavy metals. These metals are required in very small quantities for good growth of plants and animals. But, when they accumulate forming their higher concentration in the natural water bodies, they cause pollution.

Mercury is a heavy metal whose importance as a pollutant was first recognized in Japan in 1953 when in Minimata Bay there spread a disease called "**Minamata disease**" resulting in the death of 46 persons. This disease was found to be due to the consumption of fish containing methylmercury. Methylmercury is the product of mercury and is considered the worst water-soluble toxic form of mercury. However, incidents like Minamata have been frequently reported from different corners of the world since then.

Methylmercury poisoning has been reported causing "**Cat-dancing disease**" in cats in Japan.

Lead, which is used in industries and as an antiknock agent in automobile fuel, is a highly poisonous metal and affects bone marrow, formation of blood haemoglobin, and replaces calcium in bones.

Cadmium accumulates in the kidney, liver and pancreas. It interferes with certain enzymes and causes hypertension and cancer of liver and lungs. Long term exposure to cadmium causes a painful disease syndrome called "**itai-itai**" or "**ouch-ouch**" of bone.

Arsenic is also quite toxic. Populations exposed to arsenic develop peripheral vascular disturbances resulting in "gangrene" and a disease called "**Blackfoot disease**".

"**Nickel-itch**" (Nickel dermatitis) has been reported among industrial workers due to high nickel consumption. floride → Knock-Knee syndrome.

PESTICIDE POLLUTION

Variety of chemicals are often used to kill undesirable organisms in order to save or improve productivity of other desirable ones. These chemicals are collectively called "**Pesticides**".

Pesticides are of different types such as herbicides (herb killers), weedicides (weed-killers), insecticides (insect-killers), fungicides (fungus-killers), bactericides (bacterium-killers) and rodenticides (rodent-killers).

Most of the pesticides are non-persistent and biodegradable i.e. they do not persist in nature in their natural composition for long period and are acted upon by decomposer microorganisms and get broken into simpler forms.

Besides the non-persistant and biodegradable pesticides, there are a good number of pesticides which are persistant and non-biodegradable. Such pesticides find their way to water bodies, accumulate therein and harm many other non-target organisms. Example-Chlorinated hydrocarbons such as DDT, Dieldrin and Aldrin.

DDT (dichloro-diphenyl triochloroethane), a chlorinated hydrocarbon, was first discovered by a Swiss chemist, namely, P.H. Muller. DDT does not break-down easily, may remain still intact in its natural composition even after 20-25 years of its application and has been reported to pass on from one generation to another. The pesticides badly affect fishes and birds.

The pesticides organophosphate and carbonate groups are very toxic because they directly attach the enzyme cholinestrase of the nervous system.

Carbamate pesticides are manufactured MIC (methyl isocyanate). The impacts of MIC has already been discussed in atmospheric-pollution section. However, the common carbamate pesticides are Acodicarb, Baygon, Carbaryl and Carbofuran marketed under different trade names.

MARINE POLLUTION

Oceans are the ultimate sink of all natural and man-made pollutants.

Oil on water normally moves at about 1/30th of the wind speed.

Oil-spills are by far the major contributors to marine pollution.

By far the safest way of overcoming oil-spill pollution is by using biological agents for degrading oil. These agents are air-sprayed and when they mix with the oil, emulsify it and disperse it throughout the water body so thinly that it no longer remains hazardous.

Genetic Engineering may come forward to help solve this problem. This aspect is dealt under section.

SOIL POLLUTION

There are many natural and synthetic materials that adversely affect the physical, chemical and biological properties of soil resulting decrease in its productivity.

Soil may get polluted by the direct effect of dumping and disposal of wastes, application of agrochemicals or the indirect result of air-pollution such as acid-rain.

Many of the agrochemicals, specially the pesticides, reduce the biotic population (of microorganisms most importantly) which affect the structure and fertility of soil.

Many pesticides or their degradation products get absorbed by the plants via soil and thereby affect the entire food-chains and food-web.

It has been found that magnesite dust badly damages soil property such as rise of pH, decrease in exchangeable K, Ca, Mg and available P and K almost to a critical level.

It is advocated that the use of chemical fertilizers and pesticides should be reduced and the requirements be supplemented with organic manures and biofertilizers and biological control devices.

Municipal Solid Waste

The waste from homes, offices, stores, schools, hospitals, etc., that are collected and disposed by the municipality is called Municipal solid wastes. All waste that we generate can be categorised into three types :

(a) Bio-degradable

(b) Recyclable and

(c) Non-biodegradable

Burning reduces the volume of the wastes, although it is not completely burnt however open dumps often serve as the breeding ground for rats and flies. Sanitary landfills were adopted as the substitute for open-burning dumps in which wastes are dumpled in a depression or trench after compaction and covered with dirt everyday.

A case study of Remedy for Plastic Waste

A plastic sack manufacturer Ahmad Khan, in Bangalore synthesised a fine powder of recycled modified plastic. This mixture is mixed with bitumen that is used to lay roads. It enhanced the bitumen's water repellant properties, and helped to increase road life three times.

Electronic wastes (e-wastes) : Irreparable computers and other electronic goods are known as electronic wastes (e-wastes), which are buried in landfills or incinerated. However, recycling is the only solution for the treatment of e-wastes.

RADIOACTIVE POLLUTION

Radioactive pollution can be said to be a special or physical pollution related to all major life-supporting systems-air, water and soil.

The radioactive materials are transformed into gases and fine particles which are thrown high up into the air. The radioactive particles are then carried away by the wind and spread to wide areas. They finally settle down causing pollution of water and soil.

Man-made sources of radioactive pollution are mining and refining of **plutonium and thorium,** production and explosion of nuclear weapons, nuclear power plants and fuels, and preparation of radioactive isotopes.

Radioactive pollution was first experienced by common man when two atomic bombs were exploded in Nagasaki and Hiroshima (Japan) in August 1945.

Another major example is of **Chernobyl nuclear power plant** (USSR) on April 25, 1986. Radioactive material was thrown in the form of nuclear cloud in atmosphere at the time of routine safety-test-operation as the control system went suddenly out of control.

A roentgen or rad is a unit of radiation dosage.

A typical tental X-ray delivers a local dose of 1-5 rads.

Dosage of 100-250 rads do not become fatal. A man begins to suffer from fatigue, vomitting, nausea, and hair-lose. In these cases recovery is possible.

Dosase of 400-500 rads results in damage to bone marrow, reduction in WBCs, reduction in resistance against pathogens. The blood clotting fails and the affected person dies of infection and bleeding.

It is thought that the most common and dreaded delayed-effect of radioactive pollution is cancer. Workers handling radioactive wastes get slow but continued irradiation and develop cancer of different types in course of time.

[Pg→81 Chart]

NOISE POLLUTION

Noise can be simply defined as "**Unwanted sound**". However, the intensity of sound is accepted as a criterion for noise pollution.

Intensity of sound is measured in a scale called "decibel" or "dB" scale. The intensity of sound of :

Ruslting of leaves is 10 dB.

Very quiet place is 20 dB.

Libraries with soft whispers is 30 dB.

Average living room is 40 dB.

Light traffic noise is 50 dB.

Normal conversations is 60 dB.

Cars, motorcycles, trucks etc is 70-80 dB.

Jet plane upto 300 height is 100-110 dB.

Present day truck horns is 110-120 dB.

Jet plane at take off point is 150 dB.

Rocket engine is 180-195 dB.

Sound > 80db → pollution.
brief exposure of 150db causes damage to ear drums.

One generally feels annoyance when the intensity of sound reaches 75-85 dB.

The most immediate and acute effect of noise pollution is the loss of hearing. But, the loss of hearing is not the most serious consequence of noise pollution. The more dangerous consequences are : excessive anxiety, fatigue, fright and change in heart beat rates, dilation of eye pupils, blood vessel constriction, brain and liver damage.

Ultrasonics (sound above 20,000 hertz cycle/second frequency) can not be heard. This sound is thought to kill decomposer microorganisms in nature.

GREEN HOUSE EFFECT

The Greenhouse is a natural occurring phenomenon which is responsible for heating of Earth's surface and atmosphere. The average temperature at surface of Earth without green house effect would have been – 18°C rather than the present average of 15°C.

The phenomenon in which atmospheric greenhouse gases control the escape of heat from the Earth's surface to outer space so as to keep it warm and hospitable is known as greenhouse effect (Fig. 4.4).

Radioactive pollut
e-waste → arsenic, barium, be, Cd, Cr, Pb, Li, Hg, Ni, rare earth elements Europium, Sellanium, ZnS,

influx of radiations takes place. & is imp: for warming

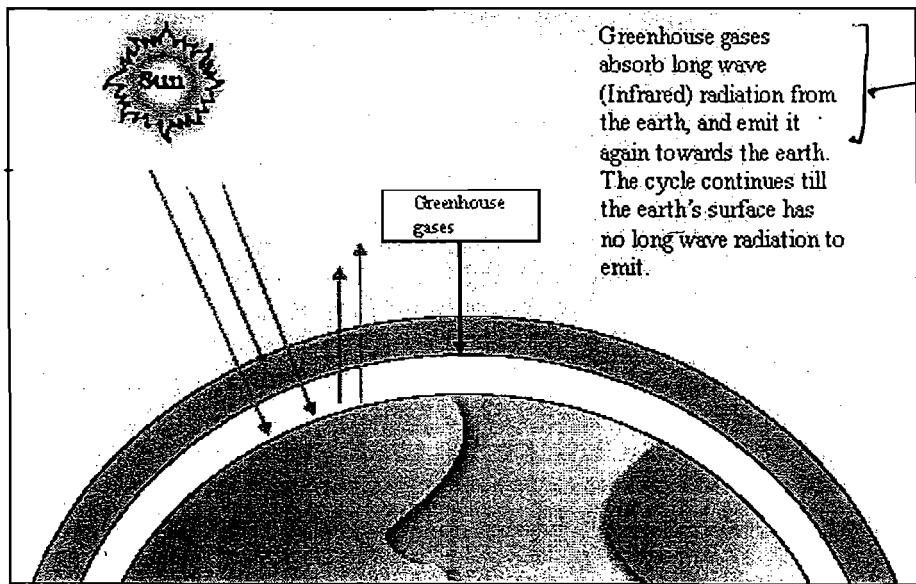



Fig. 4.4. Sunlight energy at the outermost atmosphere

Greenhouse gases (CO_2, CH_4, N_2O and CFCs) are also called radioactively active gases because it can absorb long wave infrared radiation (Fig.4.5).

CO_2 & CH_4 are major components of greenhouse gases.

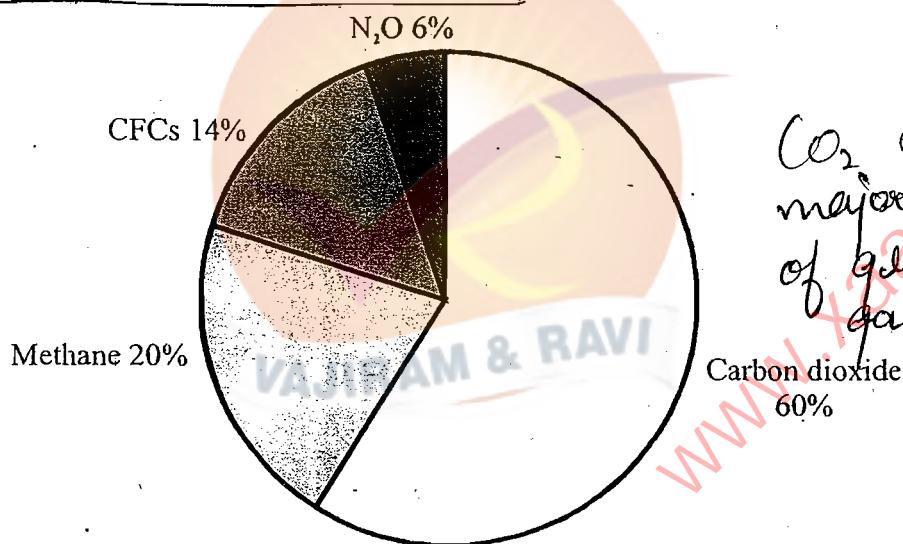



Fig. 4.5. Relative contribution of various greenhouse gases to total global warming.

The increased amount of these gases in the atmosphere are effecting the global climate which is called Global Climate Change, which leads it global warming.

During the past century, the temperature of Earth has increased by 0.6°C. This rise in temp. is leading to anomalies in climatic conditions (El Nino effect).

EL NINO EFFECT : It is a global coupled ocean-atmosphere phenomenon which was first described by G.T. Walker (1923). It is the important temperature fluctuations in surface waters of the tropical Eastern Pacific Ocean. It is usually noticed around Christmas time in the Pacific Ocean off the west coast of South America.

Q> Which is not responsible for prodn of CO_2?
Ans> Photosynthesis b/coz in this consumption of CO_2 takes place not the prodn.

El Nino causes weather patterns which causes it to rain in specific places but not in others, this is one of many causes for the drought.

El Nino is officially defined as sustained sea surface temperature anomalies of magnitude greater than 0.5°C across the central tropical Pacific Ocean. When the condition is not for a period of less than five months, it is called El Nino conditions, however, if anomaly persist for five months or longer it is called El Nino episode. Historically, it has occurred at irregular intervals of 2.7 yrs. and has usually lasted one or two yrs.

Kyoto Protocol : Approved by a follow-up conference held in Kyoto (Japan) during December 1997. It requires countries to take appropriate measures to reduce their overall green house gas emissions to a level at least 5% below the 1990 level by the commitment period 2008-2012.

OZONE DEPLETION

A slow, steady decline of about 4% per decade in the total amount of Ozone in Earth's stratosphere since around 1980.

OZONE HOLE :

Antarctic ozone hole was discovered by British Antarctic Survey scientists Farman, Gardiner and Shanklin (1985).

Seasonal decrease in thinning in stratospheric Ozone over Earth's polar regions during the same period is called O_3 hole.

The Antarctic O_3 hole is an area of the Antarctic stratosphere in which the recent ozone levels have dropped to as low as 33% of their pre-1975 values. The ozone hole occurs during the Antarctic spring, from September to early December (Fig.4.6).

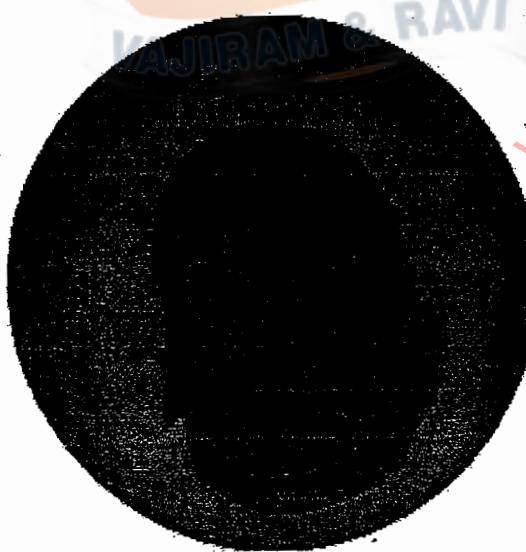



Fig. 4.6. Ozone hole over Antarctica

O_3 is found in the stratosphere and acts as a shield absorbing UV radiations from the Sun. (Mainly UV-13 wavelength 270-315 nm).

The thickness of the Ozone in a column of air from the ground to the top of the atmosphere is measured in terms of Dobson Units (DU).

The balance between production and degradation of O_3 has been disrupted due to enhancement of Ozone depleting substances like CFCs. CFCs discharged in the lower part of atmosphere move upward. In stratosphere, UV rays act on them releasing Cl atoms which acts as a catalyst in O_3 degradation. Hence, whatever CFCs are added to the atmosphere have permanent and continuing effects on O_3 levels.

Montreal Protocol

It was signed at Montreal (Canada) in 1987 (effective in 1989) to control the emission of O_3 deploting substances To-date more than 175 countries have signed the Montreal Protocol.

Deforestation

It is the conversion to forested areas to non-forest land use such as arable land, pasture, urban use, logged area or wasteland. Generally the removal or destruction of significant areas of forest cover has resulted in a degraded environment with reduced biodiversity.

The combined effect of livestock herding and fires can be a major cause of deforestation in dry areas. In addition to the direct effects brought about the forest removal, indirect effects caused by edge effects and habitat fragmentation can greatly magnify the effects of deforestation.

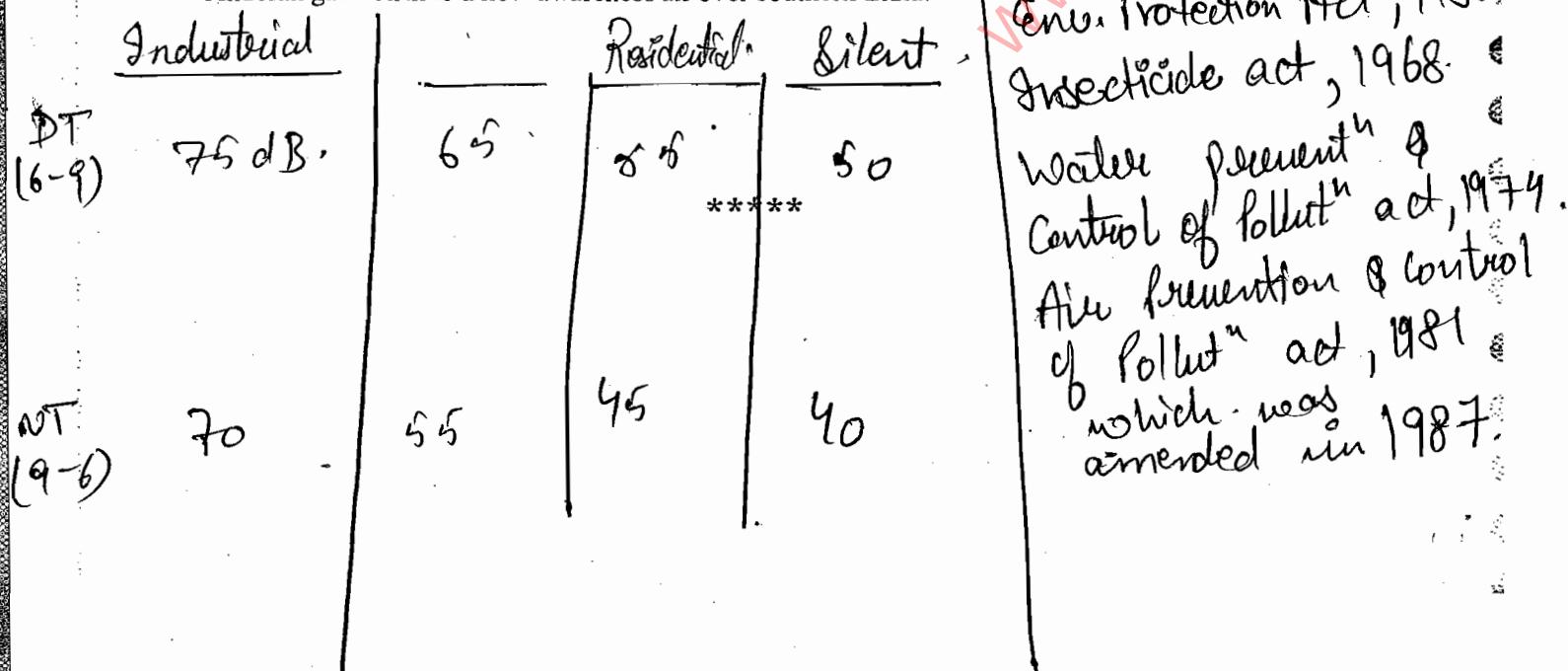
The continual degradation of forest habitat is primarily due to human related causes. Agriculture, slash and burn practises (jhoom cultivation), urban sprawl, unsustainable forestry practices, mining, and petroleum exploration all contribute to human-caused deforestation. Natural deforestation can be linked to tsunamis, forest fires, volcanic eruptions, glaciation and desertification, although the desertification process is driven primarily by human causes.

Also causes loss of biodiversity due to habitat destruction, disturbs hydrological cycle, causes soil erosion and may lead to desertification in extreme cases.

According to an estimate almost 40% forests have been lost in the tropics, compared to only 1% in the temperate region. At the end of 20th century only 19.4% forest cover was present in India. Although, National Forest Policy (1988) of India has recommended 33% forest cover for the plains and 67% for the hills.

A case study of People's participation in conservation of forests

A Bishnoi woman **Amrita Devi**, her three daughters and hundreds of other Bishnoi's sacrificed their lives for the cause of environment in 1731 at Jodhpur.

The Government of India has recently instituted the Amrita Devi Bishnoi wildlife Protection Award for individuals or communities from rural areas that have shown extraordinary coverage and dedication in protecting wildlife.

UV light is of 3 types→
UVA – 0.1 to 0.28 microm
UVB – 0.28 to 0.32 mm

Chipko movement : The Chipko movement was a group of villagers in the Uttrakhand region of India who opposed commercial logging. The movement is best known for its tactic of hugging trees to prevent them being cut down. This gave raise to the term tree hugger. Sunder Lal Bahaguda coined the Chipko Slogan : 'ecology is permanent economy'. The first Chipko took place spontaneously in April 1973 in the village of Mandal in the upper Alakananda valley and over the next five years spread to many districts of the Himalays in Uttrakhand. With encouragement from a local NGO, DGGS (Dasoli Gram Swarajya Sangh), the women of the area, under the leadership of an activist, **Chandi Prasad Bhatt**, went into the forest and formed a circle around the trees preventing the men from cutting them down.

Appiko movement : The Appiko movement was a revolutionary movement based on environmental conservation in India. The "Chipko Andolan" (Hug the Trees Movement) in Uttrakhand in the Himalayas inspired the villagers of the Uttara Kannada district of Karnataka Province in southern India to launch a similar movement to save their forests. In September 1983, men, women and children of Salkani "hugged the trees" in Kalase forest. (The local term for "hugging" in Kannada is appiko). Appiko Andolan gave birth to a new awareness all over southern India.

	Industrial		Residential	Silent
DT (6-9)	75 dB.	65	55	50
NT (9-6)	70	55	45	40

Env. Protection Act, 1986.
Insecticide act, 1968.
Water prevention & Control of Pollution act, 1974.
Air prevention & control of Pollution act, 1981 which was amended in 1987.

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Environmental Impact Assessment (EIA)

Environmental Protection and Sustainable Development have been the cornerstones of the policies and procedures governing the industrial and other developmental activities in India. Ministry of Environment & Forests has taken several policy initiatives and enacted environmental and pollution control legislations to prevent indiscriminate exploitation of natural resources and to promote integration of environmental concerns in developmental projects. One such initiative is the Notification on Environmental Impact Assessment (EIA) of developmental projects issued on 27.1.1994 under the provisions of Environment (Protection) Act, 1986 making EIA mandatory for 29 categories of developmental projects.One more item was added to the list in January, 2000.

EIA is a planning tool that is now generally accepted as an integral component of sound decision-making. The objective of EIA is to foresee and address potential environmental problems/concerns at an early stage of project planning and design.EIA/EMP should assist planners and government authorities in the decision making process by identifying the key impacts/issues and formulating mitigation measures.

The Need for EIA

Every anthropogenic activity has some impact on the environment. More often it is harmful to the environment than benign. However, mankind as it is developed today cannot live without taking up these activities for his food, security and other needs. Consequently, there is a need to harmonise developmental activities with the environmental concerns. Environmental impact assessment (EIA) is one of the tools available with the planners to achieve the above-mentioned goal.

It is desirable to ensure that the development options under consideration are sustainable. In doing so, environmental consequences must be characterised early in the project cycle and accounted for in the project design.

The objective of EIA is to foresee the potential environmental problems that would arise out of a proposed development and address them in the project's planning and design stage. The EIA process should then allow for the communication of this information to:

(a) the project proponent;
(b) the regulatory agencies; and,
(c) all stakeholders and interest groups.

EIA integrates the environmental concerns in the developmental activities right at the time of initiating for preparing the feasibility report. In doing so it can enable the integration of environmental concerns and mitigation measures in project development. EIA can often prevent future liabilities or expensive alterations in project design.

Indian Policies Requiring EIA

The environmental impact assessment in India was started in 1976-77 when the Planning Commission asked the then Department of Science and Technology to examine the river-valley projects from environmental angle. This was subsequently extended to cover those projects, which required approval of the Public Investment Board. These were administrative decisions, and lacked the legislative support. The Government of India enacted the Environment (Protection) Act on 23rd May 1986. To achieve the objectives of the Act, one of the decisions that were taken is to make environmental impact assessment statutory. After following the legal procedure, a notification was issued on 27th January 1994 and subsequently amended on 4th May 1994, 10th April 1997 and 27th January 2000 **(Annex 1)** making environmental impact assessment statutory for 30 activities.This is the principal piece of legislation governing environmental impact assessment. Imp.

Besides this the Government of India under Environment (Protection) Act 1986 issued a number of other notifications, which are related to environmental impact assessment.These are limited to specific geographical areas. It contains:

- Prohibiting location of industries except those related to Tourism in a belt of 1 km from high tide mark from the Revdanda Creek up to Devgarh Point (near Shrivardhan) as well as in 1 km belt along the banks of Rajpuri Creek in Murud Janjira area in the Raigarh district of Maharashtra (6th January 1989)
- Restricting location of industries, mining operations and regulating other activities in Doon Valley (1st February 1989)
- Regulating activities in the coastal stretches of the country by classifying them as coastal regulation zone and prohibiting certain activities (19thFebruary 1991)
- Restricting location of industries and regulating other activities in Dahanu Taluka in Maharashtra (6th June 91)
- Restricting certain activities in specified areas of Aravalli Range in the Gurgaon district of Haryana and Alwar district of Rajasthan (7th May 1992)
- Regulating industrial and other activities, which could lead to pollution and congestion in an area north west of Numaligarh in Assam (5th July 1996)

V.Imp Sequence Procedure

The EIA Cycle and Procedures

The EIA process in India is made up of the following phases:

- Screening
- Scoping and consideration of alternatives
- Baseline data collection
- Impact prediction
- Assessment of alternatives, delineation of mitigation measures and environmental impact statement
- Public hearing
- Environment Management Plan
- Decision making
- Monitoring the clearance conditions

Screening

Screening is done to see whether a project requires environmental clearance as per the statutory notifications. Screening Criteria are based upon:

- Scales of investment;
- Type of development; and,
- Location of development.

Scoping

Scoping is a process of detailing the terms of reference of EIA. It has to be done by the consultant in consultation with the project proponent and guidance, if need be, from Impact Assessment Agency.

Baseline Data

Baseline data describes the existing environmental status of the identified study area. The site-specific primary data should be monitored for the identified parameters and supplemented by secondary data if available.

Impact Prediction

Impact prediction is a way of mapping the environmental consequences of the significant aspects of the project and its alternatives.
Environmental impact can never be predicted with absolute certainty and this is all the more reason to consider all possible factors and take all possible precautions for reducing the degree of uncertainty.

The following impacts of the project should be assessed:

Air

- changes in ambient levels and ground level concentrations due to total emissions from point, line and area sources
- effects on soils, materials, vegetation, and human health

Noise

- changes in ambient levels due to noise generated from equipment and movement of vehicles
- effect on fauna and human health

Water

- availability to competing users
- changes in quality
- sediment transport
- ingress of saline water

Land

- changes in land use and drainage pattern
- changes in land quality including effects of waste disposal
- changes in shoreline/riverbank and their stability

Biological

- deforestation/tree-cutting and shrinkage of animal habitat.
- impact on fauna and flora (including aquatic species if any) due to contaminants/pollutants
- impact on rare and endangered species, endemic species, and migratory path/route of animals.
- Impact on breeding and nesting grounds

Socio-Economic

- impact on the local community including demographic changes.
- Impact on economic status
- impact on human health.
- impact of increased traffic

Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact Assessment Report

For every project, possible alternatives should be identified and environmental attributes compared. Alternatives should cover both project location and process technologies. Alternatives should consider no project option also. Alternatives should then be ranked for selection of the best environmental option for optimum economic benefits to the community at large.

Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements. The EMP is a crucial input to monitoring the clearance conditions and therefore details of monitoring should be included in the EMP.

An EIA report should provide clear information to the decision-maker on the different environmental scenarios without the project, with the project and with project alternatives. Uncertainties should be clearly reflected in the EIA report.

Public Hearing

Law requires that the public must be informed and consulted on a proposed development after the completion of EIA report.

Any one likely to be affected by the proposed project is entitled to have access to the Executive Summary of the EIA.

They are to be given an opportunity to make oral/written suggestions to the State Pollution Control Board.

Decision Making

Decision making process involve consultation between the project proponent (assisted by a consultant) and the impact assessment authority (assisted by an expert group if necessary)

The decision on environmental clearance is arrived at through a number of steps including evaluation of EIA and EMP.

Components of EIA

The difference between **Comprehensive** EIA and **Rapid** EIA is in the time-scale of the data supplied. Rapid EIA is for speedier appraisal process. While both types of EIA require inclusion/ coverage of all significant environmental impacts and their mitigation, Rapid EIA achieves this through the collection of one season (other than monsoon) data only to reduce the time required. This is acceptable if it does not compromise on the quality of decision-making. The review of Rapid EIA submissions will show whether a comprehensive EIA is warranted or not.

Rapid EIA -> req. very low time, only one season.

(NGT) National Green Tribunal -> has been established on 18 Dec' 2010 under the NGT Act for disposal of cases relating to env. protectn & conservatn of forests and other natural resources including enforcement of any legal right relating to env.

BIOENERGY, BIOFERTILISERS & BIOLOGICAL PEST CONTROL

BIOENERGY

Bioenergy is the energy obtained from living organisms. It does not include fossil fuels. It consists of two sources-animal energy and biofuels, which are briefly discussed below :

Animal Energy

The work done by human beings and the domesticated animals is equivalent to 20% of the total electricity production of our country. The two types of animal energy are termed Human Muscle Power (HMP) and Draught Animal Power (DAP). The entire labour force involved in industries, agriculture and building works and the horses, bulls-pulling carts, elephants pulling huge wooden logs in forests, etc. are examples of animal energy.

BioFuels

Biofuels are the fuels obtained from renewable sources of biological origin e.g., agricultural, agro-industrial wastes, wood, and alcohol, oil and petroleum yielding plants. These alternative sources of energy may prove to be very good substitutes of the non-renewable fossil fuels. These biofuels produce biogas, electricity, alcohol, heat, charcoal, petroleum products, etc. Some of the sources of biofuels are discussed below :

Wood

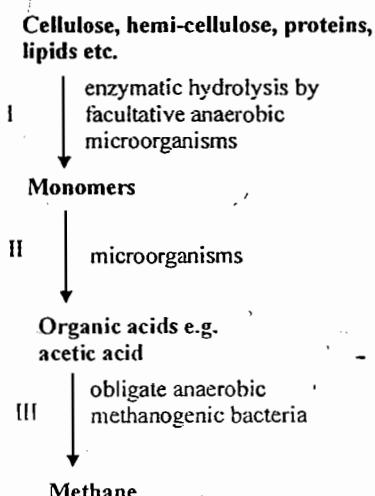
Wood is widely used as domestic fuel resulting in large scale deforestation. A good quality fuel wood is easily dried up, is easily burnt, release plenty of heat in a uniform manner and is smokeless e.g. the hardwood (dicolyledonus). The softwood (monocotyledonous) plants are resinous, and get quickly burnt up and are, therefore, not desirable as fuel. A list of firewood sources is given below :

A list of good and bad sources of firewood in India

	Good Firewood Trees		Bad firewood Trees
1.	*Dalbergia sissoo*	1.	*Mangifera indica*
2.	*Azadirachta indica*	2.	*Bombax ceiba*
3.	*Acacia nilotica*	3.	*Bauhinia racemosa*
4.	*Acacia senegal*	4.	*Madhuca indica*
5.	*Prosopis cineraria*	5.	*Michelia excelsa*

7. *Terminalia tomentosa*
8. *Adina cordifolia*
9. *Quercus spp.*
10. *Hopea sp.*
11. *Albizzia spp.*

The qualities of a good firewood are as follows :

(i) ability to burn up
(ii) generation of maximum heat
(iii) heat generated should be uniform over a long period of time
(iv) smoke released is minimum
(v) no foul odour
(vi) gets dried up easily
(vii) goes not contain resin
(viii) does not split up during burning.

Energy plantations

The large scale plantation of suitable species of trees on vacant lands, roadside and railway tracks, wastelands, etc. can result in tremendous increase in sources of energy. Preference is given to species which have multiple uses, are easily grown having very rapid rate of growth. The species should be hardy requiring low amount of water and fertilizer and should regenerate fast into several branches when cut. Social forestry is becoming popular since it provides firewood, fodder, minor timbers, etc. to the public. In order to get maximum advantage the agro-technology should be developed for growing species in specific habitats.

Energy from waste materials

Cattle dung is known to be used as manure and fuel. When it is used as a fuel there is a huge wastage of the calories and only a small percentage of energy is useful. The dung is today fermented anearobically to generate biogas (fuel) and the residue is used as a fertiliser.

The biogas can be produced from a number of animal waste. It consists of 50-70% methane, 30-40% CO_2 and traces of nitrogen, hydrogen and hydrogen sulphide. The biogas generation involves 3 steps which are as follows :

Its burning is very efficient. Its caloric value is 23 - 28 MJ/m^3. Besides it does not contribute to pollution.

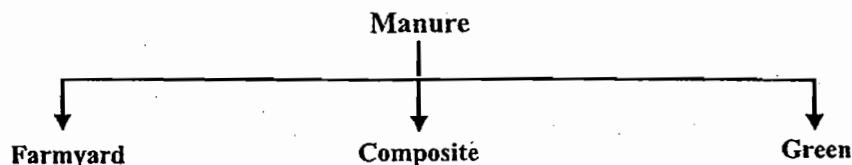
The various sources of biogas are as follows :

(i) Animal wastes
(ii) Human wastes
(iii) Urban solid wastes
(iv) Acuatic plants
(v) Byproducts and wastes of agro-industries
(vi) Forest residues.

Advantages of biogas production from wastes

1. The wastes are usefully disposed off.
2. The pathogens which thrive on the wastes are also eliminated and do not survive till next year.
3. The residue can be used as a fertiliser.
4. The biogas can be used in various ways.
5. The biogas occupies less space and can be easily stored and used when required.

Petroleum plants

Plants are not known to be a source of petroleum but there are reports that latex yielding members of the families Euphorbiaceae, Asclepiadaceae and Apocyanaceae contain liquid hydrocarbons which might yield petroleum.

Alcohol Fuel

Plants like tapioca (*Manihot sp*.), sugarcane, sugarbeet, maize, etc. are very good sources of alcohol, but they have yet to be commercially exploited.

Indian soils are usually poor in organic matter as well as in nitrogen.

MANURE

Manures are materials added to soil to increase crop productivity. They provide practically all the nutrient elements required by crops.

Farmyard	Composite	Green
It consists of a mixture of cattle dung and crop residues (remnants of straw and plant stalks fed to cattle).	It consists of rotted vegetables and animal refuse.	A quick-growing crop is cultivated and ploughed under, to incorporate it into the soil. It supplies organic matter and additional nitrogen and also exercises a protective action against erosion and leaching.

Plants most commonly used as green Manures in India	
Common name	***Botanical name***
Sunn hemp	*Crotalaria juncea*
Dhaincha	*Sesbania aculeate*
Cluster bean	*Cyamopsis tetragonoloba*
Senji	*Melilotus parviflora*
Cowpea	*Vigna sinensis*
Horse-gram	*Macrotyloma uniflorum*
Berseem (Egyptian clover)	*Trifolium alexandrinum*
Lentil (Masur)	*Lens esculenta*

BIOFERTILISERS

Biofertilisers are organisms which can bring about soil nutrient enrichment. The main sources of biofertilisers are bacteria, cyanobacteria and fungi.

(i) ***Legume-Rhizobium symbiosis :*** *Rhizobium* produces nodules in the roots of leguminous plants and fixes atmospheric nitrogen. Phosphorus is also required at optimal levels for better nitrogen fixation. Therefore, a combination of phosphatic fertilisers with *Rhizobium* culture is generally recommended.

(ii) ***Azolla-Anabaena symbiosis :*** *Azolla* is a small, fast-growing fern which occurs floating on water. *Anabaena azollae*, a cyanobacterium lives in cavities of *Azolla* leaves. It fixes nitrogen from the air and excretes the nitrogenous compounds into the leaf cavity of the fern. *A. pinnata* is an excellent biofertiliser for rice. Farmers have reported over 50 per cent higher yields by using *Azolla*.

(iii) ***Loose association of nitrogen fixing bacteria :*** A loose association of *Azospirillum lipoferum*, a nitrogen fixer, with the roots of certain Brazillian grasses and maize increase the yield of the plants.

(iv) ***Free-living bacteria :*** Free-living soil bacteria such as *Azotobacter* and *Bacillus polymyxa* fix atmospheric nitrogen and make it available to crops like cereals, millets, fruits and vegetables. When *Azotobacter* is grown along with cotton, rice, maize and jowar it results in increased yield and saving of nitrogen to the extent of 10-25 kg/ha.

(v) ***Cyanobacteria :*** Cyanobacteria such as *Anabaena, Nostoc* and *Aulosira* derive the energy needed for nitrogen fixation through photosynthesis. These organisms have been used as biofertilisers at the Indian Agricultural Research Institute and it is reported that up to 20-30 kg/ha of nitrogen is fixed by them.

These cyanobacteria have a potential to supply 7-8 lakh tonnes of fixed nitrogen, equivalent to 15-17 lakh tonnes of urea, sufficient to meet the needs of the entire rice crop in our country. The advantage of using cyanobacteria as biofertiliser is its low cost production which is based on a simple technology.

(vi) ***Mycorrhiza*** : *Mycorrhiza* (*Mycorrhizae* plural) is a symbiotic association of certain fungi with the roots of certain seed-bearing plants (hence the term *mycorrhiza*). Mycorrhizae can be broadly classified into two types : the ectomycorrhizae and endomycorrhizae.

Ectomycorrhiza (Ectotrophic) is a form of mycorrhizal association in which there is a well-developed mycelium forming a mantle on the outside of the root. Mycorrhizae enhance water and nutrient uptake, resulting in greater plant vigour, growth and yield. Ectomycorrhizae commonly occur on the roots of trees such as pine, oak, peach and eucalyptus. They absorb and store nitrogen, phosphorus, potassium and calcium in their fungal mantle. They also convert complex organic molecules into simpler, easily available forms.

Endomycorrhiza (Endotrophic) is a form of mycorrhizal association in which the fungus lives between and within the cells of the cortex and their growth on the outside of the root is limited. Such associations are found in many herbaceous species like orchids and certain woody plants. Endomycorrhizae are produced both by septate and non-septate fungi.

VAM : It is a form of endotrophic mycorrhizae in which the fungus lives between the cells of the cortex and forms temporary hyphal projections that penetrate into cortical cells and may form swollen ***vesicles*** or finely branched masses and crop ***arbuscules***. These are called **vesicular-arbuscular mycorrhizae** or **VAM**. VAM are important in the phosphate nutrition of plants. Many grasses and crop plants develop symbiotic association with VAM.

BIOPESTICIDES

Biopesticides (also known as biological pesticides) are certain types of pesticides derived from such natural materials as animals, plants, bacteria and certain minerals.

(a) ***Biological Control of Weeds and Bioherbicides*** **:** Biological control of weeds involves utilisation of insects that would feed selectively on a weed or use of certain microorganisms which will produce diseases in the weeds and eliminate them.

In India and Australia the overgrowth of cacti was checked by the introduction of the cochineal insect (*Cactoblastis cactorum*). The first bioherbicide was developed in 1981. It is a mycoherbicide, based on the fungus *Phytophthora palmivora*. It controls the growth of milk weed vines in citrus orchards.

The present-day emphasis is on the use of fungal spores in controlling weeds. Two products have appeared in the market; they are '**Devine**' and '**Collego**'.

* **The use of Devine :** The liquid suspension of chlamydospores of *phytophthora palmivora* for the control of milkweed vine (*Morrenia odorata*) in citrus orchards in USA.

* **The use of Collego :** A dry powder formulation of the fungus *Colletotrichum* gloesporioides for controlling northern joint-vetch (*Aeschynomena virginica*) a leguminous weed, in USA.

Microbial pesticides contain a microorganism (bacterium, fungus, virus, protozoan or alga) as the active ingredient.

(b) ***Bioinsecticides***

An ideal pesticide is one which would bring about a complete control of only the target pest (specific), is non-persistent, non-toxic and biodegradable or would otherwise lose its identity in the environment.

(i) ***Pathogens, parasites and predators :*** A number of destructive insects can be reduced by other insects, diseases, parasites or predators. This method has been applied in the control of aphids by the use of ladybugs or the praying mantis.

The most widely known microbial insecticides are varieties of the bacterium *Bacillus thuringiensis*, or **Bt**, which can control certain insects in cabbage, potatoes and other crops. Bt produces a protein that is harmful to specific insect pests.

The first commercial bioinsecticide preparation of entomopathogens for use as an agent for insect control was **"Sporeine"**. It was based on soil bacterium *Bacillus thuringiensis israelensis* (BTI).

Certain other microbial pesticides act by outcompeting pest organisms. Microbial pesticides need to be continuously monitored to ensure that they do not become capable of harming non-target organisms, including humans.

Baculoviruses are pathogens that attack insects and other arthropods. The majority of baculoviruses used as biological control agents are in the genus *Nucleopolyhedrovirus*. These viruses are excellent candidates for species specific, narrow spectrum insecticidal applications.

(ii) ***Sterilisation Strategy :*** A sophisticated approach to pest control is using the insect for its own destruction. The screw worm, a major pest, was eradicated by releasing sterile male insects (rendered sterile by irradiation) at the time of mating, to compete with the natural fertile population.

(iii) ***Insect hormones :*** Scientists have been employing insect hormones **(pheromones)** which are the principal means of communication between insects and are useful in sending alarm signals, marking trails or attracting mates.

Pheromones are secreted by the females and detected by the antennae of the males. They are species specific. Traps containing pheromones of the **gypsy moth** are placed in the infested fields. The males fly to the trap and are lured into the hollow cylinder coated inside with a sticky substance. They are thus not available for reproduction.

A variation of this approach is called the '**confusion technique**' in which large amounts of a hydrophobic paper containing the sex attractant is dropped over a cropped area. The males are no longer able to locate the females as the characteristic smell is spread all over.

The insect hormones such as the juvenile hormone and the molting hormone (ecdysone) are required for proper metamorphosis of the young ones to the adult stage. When Juvenile hormone artificially provided to the insects at later stage it develops into giant larvae and immature adults. These immature adults die rather quickly. Thus the introduction of juvenile hormones at inappropriate times results in the early death of insect pests.

(iv) ***Natural Insecticides :*** Natural insecticides are obtained mostly from plants and occasionally from microbes. The Chinese were the first to discover the insecticidal properties of **rotenones** present in the roots of *Derris elliptica*. Alkaloids such as **nicotine** from tobacco (*Nicotiana* spp.) and **pyrethrum** and **cinerin** (pyrethroids) from pyrethrum (*Chrysanthemum cinerarifolium*) are good plant insecticides.

Extracts from neem (*Azadirachta indica*) contain and antifeedant, compound, azadirachtin that keep away the insects. Foliage coated with extract of neem repel Japanese beetles and leaf-eating pests.

The bacterium *Bacillus thuringenesis* produces protein toxins. One of them is thurioside, which is active against different groups of insects including moths, flies, mosquitoes and beetles. The toxins accumulate as crystals inside the bacteria during sporulation. Upon ingestion by susceptible insects they are converted into the active form and kill them by inhibition of ion transport in the midgut. The toxins are believed to be biodegradable and inactive against mammals and animals.

Recently transgenic plants of tomato showing resistance to hornworm larvae have been obtained.

Advantages of using Biopesticides

(i) Biopesticides are inherently less harmful than conventional pesticides.

(ii) Biopesticides are designed to affect only one specific pest or in some cases, a few target organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects and mammals.

(iii) Biopesticides often are effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.

(iv) When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly decrease the use of conventional pesticides, while crop yields remain high.

Integrated Pest Management

The need of the day is Integrated Pest Management (IPM) which involves various 'cultural controls' to insure continued production of the soil without the excessive use of synthetic pesticides. Crops can be protected by eliminating the pests by the method of starvation. A preferred target crop may be planted to lure the insects away from the economic crop or mixed planting is used to cut down on the concentration of pest-attracting crop.

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Bioremediation : It is the use of any organism metabolism to remove pollutants. Technologies can be generally classified as *in situ* or *ex situ*. *In situ* bioremediation involves treating the contaminated material at the site, while *ex situ* involves the removal of the contaminated material to be treated elsewhere.

Some examples of bioremediation related technologies are *phytoremediation, bioventing, bioleaching,landfarming, bioreactor, composting, bioaugmentation, rhi zofiltration, and biostimulation.*

Bioremediation can occur on its own (natural attenuation or intrinsic bioremediation) or can be spurred on via the addition of fertilizers to increase the bioavailability within the medium (biostimulation). Recent advancements have also proven successful via the addition of matched microbe strains to the medium to enhance the resident microbe population's ability to break down contaminants. Microorganisms used to perform the function of bioremediation are known as **bioremediators.**

Not all contaminants, however, are easily treated by bioremediation using microorganisms. For example, heavy metals such as *cadmium and lead* are not readily absorbed or captured by microorganisms. A recent experiment however suggests that fish bones have some success absorbing lead from contaminated soil. Bone char has been shown to bioremediate small amounts of Cadmium Copper and Zinc. The assimilation of metals such as mercury into the food chain may worsen matters. Phytoremediation is useful in these circumstances because natural plants or transgenic plants are able to bioaccumulate these toxins in their above-ground parts, which are then harvested for removal. The heavy metals in the harvested biomass may be further concentrated by incineration or even recycled for industrial use.

The elimination of a wide range of pollutants and wastes from the environment requires increasing our understanding of the relative importance of different pathways and regulatory networks to carbon flux in particular environments and for particular compounds, and they will certainly accelerate the development of bioremediation technologies and biotransformation processes

Biofuel : A **biofuel** is a fuel that contains energy from geologically recent carbon fixation. These fuels are produced from living organisms. Examples of this carbon fixation occur in plants and micro algae. These fuels are made by a biomass conversion (biomass refers to recently living organisms, most often referring to plants or plant-derived materials). This biomass can be converted to convenient energy containing substances in three different ways: thermal conversion, chemical conversion, and biochemical conversion. This biomass conversion can result in fuel in solid, liquid, or gas form. This new biomass can be used for biofuels.

Discoveries of huge petroleum deposits kept gasoline and diesel cheap for decades, and biofuels were largely forgotten. However, with the recent rise in oil prices, along with growing concern about global warming caused by carbon dioxide emissions, biofuels have been regaining popularity.

Gasoline and diesel are actually ancient biofuels. But they are known as fossil fuels because they are made from decomposed plants and animals that have been buried in the ground for millions of years. Biofuels are similar, except that they're made from plants grown today.

Much of the gasoline in the United States is blended with a biofuel—ethanol. This is the same stuff as in alcoholic drinks, except that it's made from corn that has been heavily processed. There are various ways of making biofuels, but they generally use chemical reactions, fermentation, and heat to break down the starches, sugars, and other molecules in plants. The leftover products are then refined to produce a fuel that cars can use.

Countries around the world are using various kinds of biofuels. For decades, Brazil has turned sugarcane into ethanol, and some cars there can run on pure ethanol rather than as additive to fossil fuels. And biodiesel—a diesel-like fuel commonly made from palm oil—is generally available in Europe.

For the future, many think a better way of making biofuels will be from grasses and saplings, which contain more cellulose. If cellulose can be turned into biofuel, it could be more efficient than current biofuels, and emit less carbon dioxide.

Biofuels and India: The story so far

In India, one of the strongest contenders for the top spot as the next-best substitute for petrol and diesel is biofuel, which is extracted from the seeds of the Jatropha plant.

Extracting benefits

The use of Jatropha oil as fuel in India is not a recent phenomenon. In fact, this biodiesel has been fuelling remote rural and forest communities for many years now.

Jatropha oil is of special interest to Indian authorities for a number of reasons.

>> The Jatropha plant can easily be cultivated in wastelands. According to former Indian President, Dr Abdul Kalam, a strong believer in Jatropha as a biofuel, nearly half of the country's 6,00,000 sq. km of wasteland is suitable for Jatropha cultivation

>> Jatropha oil is cost effective, since it can be used directly after extraction, without the need for any additional refining.

>> The cultivation of Jatropha crop is relatively easier, as the leaves of these plants are unpalatable to livestock. This ensures that the plants remain intact during the sapling stage, unlike many other types of tree saplings.

>> The prolific use of this oil will eventually reduce the country's dependence on fossil fuel imports. The money thus saved can be diverted to other, more productive uses such as for building infrastructure.

>> The rapid pace of expansion within the domestic automobile industry will only increase the already overwhelming demand on the nation's meagre fossil-fuel reserves-an eventuality that can be easily circumvented with the help of biofuel

In a bid to encourage Indian farmers to take up Jatropha cultivation, the government has signed a Memorandum of Understanding with bio-oils specialist D1 Mohan Bio Oils Ltd to hand out loans worth Rs 1.3 billion to farmers; the Hindustan Petroleum Corporation Ltd (HPCL) and the Maharashtra State Farming Corporation Ltd have jointly set up a Jatropha seed-based biodiesel venture, while Chattisgarh is well on its way to becoming a biofuel self-reliant state by the year 2015.

Biofortification

Biofortification is the idea of breeding crops to increase their nutritional value. This can be done either through conventional selective breeding, or through genetic engineering. Biofortification differs from ordinary fortification because it focuses on making plant foods more nutritious as the plants are growing, rather than having nutrients added to the foods when they are being processed. This is an improvement on ordinary fortification when it comes to providing nutrients for the rural poor, who rarely have access to commercially fortified foods. As such, biofortification is seen as an upcoming strategy for dealing with deficiencies of micronutrients in the developing world.

Genetic modification

Golden Rice is an example of a GM crop developed for its nutritional value. The latest version of Golden Rice contains genes from a common soil bacterium Erwinia and maize, and contains increased levels of beta-carotene which can be converted by the body into vitamin A. Golden Rice is being developed as a potential new way to address vitamin A deficiency.

In one trial in Mozambique, eating sweet potatoes biofortified with beta-carotene reduced the incidence of vitamin A deficiency in children

Biofortified foods may also be useful for increasing micronutrient uptake in high-income countries. An example of this trend would be research into grain with higher levels of **selenium**, which, amongst other benefits, helps prevent prostate cancer. Researchers at the University of Warwick have been looking for ways to boost the low selenium levels in British grains, and have been working to help develop a grain to be used in making bread biofortified with selenium.

Biofortification is the process by which the nutritional quality of staple crops is enhanced. This is done through conventional plant breeding and/or modern technology. More research is needed, but it is hoped that people who consume biofortified crops will have an improved nutritional intake.

Various biofortification projects are underway, including:

- Iron-biofortification of rice, beans and sweet potato
- zinc-biofortification of wheat, rice, beans, sweet potato and maize
- provitamin A carotenoid-biofortification of sweet potato, maize and cassava

Prebiotic and Probiotic

Prebiotics *are not* probiotics.

Probiotics are live bacteria in yogurt, other dairy products and pills. And while probiotics have been shown effective in managing certain gastrointestinal conditions, they do not have the same power that prebiotics do. First, they're delicate — heat and stomach acid can kill them, rendering them ineffective before they've even been digested. Also, those who don't eat dairy foods for taste or dietary reasons may find ingesting adequate amounts of probiotics difficult, if not impossible.

Prebiotic : In short, the Prebiotic is a specialized plant fiber that beneficially nourishes the good bacteria already in the large bowel or colon. The body itself does not digest these plant fibers; instead, the fibers act as a fertilizer to promote the growth of many of the good bacteria in the gut. These, in turn, provide many digestive and general health benefits.

The Prebiotin formula of prebiotic supplements contains both insulin and oligofructose. This full spectrum formula treats the entire bowel wall for maximum effectiveness. And Prebiotin has been proven by numerous independent scientific studies to increase the number of healthy bacteria in the colon, the benefits of which are impressive and essential to overall health and well being.

PREBIOTIC VS PROBIOTIC

PREBIOTICS	PROBIOTICS
PREBIOTICS are a special form of dietary fiber	PROBIOTICS are live bacteria in yogurt, dairy products and pills. There are hundreds of probiotic species available. Which of the hundreds of available probiotics is best is still unknown.
PREBIOTIC powders are not affected by heat, cold, acid or time.	PROBIOTIC bacteria must be kept alive. They may be killed by heat, stomach acid or simply die with time.
PREBIOTICS provide a wide range of health benefits to the otherwise healthy person. Most of these have been medically proven.	PROBIOTICS are still not clearly known to provide health benefits to the otherwise healthy. Some are suspected but still not proven.
PREBIOTICS nourish the good bacteria that everyone already has in their gut.	PROBIOTICS must compete with the over 1000 bacteria species already in the gut.
PREBIOTICS may be helpful or preventative for irritable bowel (IBS), or inflammatory bowel disease (Crohn's Disease,Ulcerative Colitis), colon polyps and cancer and those people with a leaky gut.	Certain PROBIOTIC species have been shown to be helpful for irritable bowel disease and for recurrence of certain bowel infections such as C. difficile.

Applications of Recombinant products

Medically useful recombinant products	Applications
Human Insulin	Treatment of insulin – dependent diabetes
Human Growth Hormone	Replacement of missing hormone in short stature people.
Calcitonin	Treatment of rickets.
Chorionic gonadotropin	Treatment of infertility.
Blood clotting Factor VIII/IX	Replacement of clotting factor missing in patients with Haemophilla A/B.
Tissue Plasminogen activator (TPA)	Dissolving of blood clots after heart attacks and strokes.
Erythropoetin	Stimulation of the formation of erythrocytes (RBCs) for patients suffering from anaemia during dialysis or side effects of AIDS patients treated by drugs.
Platelet derived growth factor	Stimulation of wound healing
Interferon	Treatment of pathogenic viral infections, cancer
Interleukin	Enhancement of action of immune system
Vaccines	Prevention of infectious diseases such as hepatitis B, herpes, influenza, pertusis, meningitis, etc.

Application of Genetically Engineered Microbes

Microbes	Applications
Escherichia coli (gut bacterium)	Production of human insulin, human growth factor interferons, interleukin and so on.
Bacillus thuringiensis (soil bacterium)	Productions of endotoxin (Bt toxin), highly potent, safe and biodegradable insecticide for plant protection.
Rhizobium meliloti (bacterium)	Nitrogen fixation by incorporating "nif" gene in cereal crops.
Pseudomonas putida (bacterium)	Scavenging of oil spills by digesting hydrocarbons of crude oil.
Bacterial strains capable of accumulating heavy metal	Bioremediation (cleaning of pollutants in the environment)
Trichoderma (fungus)	Production of enzyme chitinases for biocontrol of fungal diseases in plants.

Transgenics and their potential applications

Transgenic	Useful application
Bt Cotton	Pest resistance, herbicide tolerance and high yield
Flavr Savr Tomato	Increased shelf-life (delayed ripening) and better nutrient quality
Golden Rice	Vitamin A and Fe-rich
Cattles (cow, sheep, goat)	Therapeutic human proteins in their milk
Pig	Organ transplantation without risk of rejection

Important Alkaloids and their sources

Name of Alkaloid	Source	Use
(1) Morphine	Capsule of ***Papaver somniferum***	Analgesic and sedative
(2) Codeine	-do-	Cough and cold
(3) Reserpine	Roots of ***Rauwolfia serpentina***	Lower blood pressure
(4) Quinine	Bark of ***Cinchona officinalis***	Malaria
(5) Atropine	Leaves of ***Atropa balladona***	Dilates pupil of eye
(6) Ephedrine	Entire plant (Mainly stem) of ***Ephedra***	Cough, Asthama
(7) Curcumine	Rhizome of ***Curcuma longa***	Antihelmintic
(8) Aconita	Roots of ***Aconitum napellus***	Neuralgia and Rheumatism
(9) Cocaine	Leaves of ***Erythroxylon coca***	Local anaesthetic
(10) Strychine	Seeds of ***strychnos nuxvomica***	Nervous disorder

Population, Biotic Community & Succession

BIOTIC COMMUNITY

Biotic Community is a grouping of different but interacting populations of different species which live harmoniously in a given locality, e.g., pond community, lawn community, forest community. Each member of biotic community is called species. It is represented by a population.

Population is a near permanent group of interbreeding individuals of a species found in a space or geographical area at a particular time. It is called **local population** or **deme**.

Different local populations of a species are connected by dispersal individuals.

Metapopulation is a complex of local populations connected by dispersing individuals. Population carries a different meaning in different areas of study.

Human demography is the population representing the number of human beings in a given area. Eg. : School, village, town, state, country or whole-earth.

Population ecology is the study of all aspects of a population and the various factors affecting it in its growth, density, size, multiplication, natality, mortality, competition, tolerance, etc.

POPULATION CHARACTERISTICS

Population Density. It is the number of individuals (of a species) per unit area/space at a given time.

In case of aquatic habitat, the space is measured in three dimensions (e.g., cubic metre) while the area of a terrestrial habitat is measured in two dimensions (e.g., square metre). Unit of area depends upon the size and number of individuals. eg. : tiger / 100 km^2, deer/10 km^2, pinetnees/hectoure

However, density of a population may vary from time to time and area to area, e.g., density of small plants in rainy season and dry season, winter or summer population of mosquitoes/flies.

Population size also depends upon availability of nutrients and other resources for it.

Natality (Birth Rate)

It is the rate of production of new individuals per unit of population per unit time through birth, hatching, germination or vegetative propagation.

The maximum natality or birth rate achieved under ideal conditions is called **biotic potential** (represented by 'r').

The actual birth rate found under existing conditions is termed as **realised natality**. In human beings, natality or birth rate is calculated per thousand per year.

Mortality (Death Rate)

It is the rate of loss of individuals per unit time due to death. **Specific mortality** (= minimum mortality) is the theoretical, minimum death rate that occurs under ideal conditions due to natural process of senescence.

Maximum mortality occurs in stages of egg, larva, seedling and old age.

In human population mortality is calculated per thousand per year.

Vital index : It is the percentage ratio of natality in relation to mortality.

Vital index determines the normal rate of population growth.

Vital index = N/M × 100

Population Dispersal

It is the movement of individuals or propagules into or out of population for preventing over crowding, obtaining food, avoiding predators and other adverse conditions. It affects the size of population.

Population dispersal can be of three types :

(i) **Emigration.** Permanent outward movement of individuals from a given population. It decreases the size of local population.

(ii) **Immigration.** Permanent inward/coming of individuals from outside into a population. It increases the size of local population.

(iii) **Migration.** It is a two-way movement of entire population to avoid unfavourable conditions. It does not change the size of population.

Age Distribution

Ecologically a population has three age groups–**pre-reproductive, reproductive** and **post-reproductive**. Their comparative abundance determines the reproductive status of population. A population having larger number of young individuals will show rapid increase (positive growth). It will have a slow increase or become static (zero growth) if various age groups are evenly balanced.

A population with large number of post-reproductive or older individuals can show a negative growth rate.

Age Pyramids : Graphic representation of different age-groups found in a population with pre-reproductive groups at the base, reproductive ones in the middle and post-reproductive groups at top is called 'age pyramid'

Are of three types:

(i) Triangular age pyramid : (Exapanding population)

No. of pre-reproductive individuals : very large

No. of reproductive individuals : moderate

No. of post-reproductive individuals : very few

Population growth depends upon the comaparative size of pre-reproductive population.

(ii) **Bell shaped age pyramid :** (stable population)

No. of pre-reproductive individuals ≡ reproductive individuals

No. of post reproductive individuals = fewer (comparatively)

Population size – stable, neither growing nor diminishing

(iii) **Urn shaped age pyramid :**

No. of reproductive age group > no. of pre-reproductive age group.

No. of post reproductive individuals = Small

Population – declining or diminishing with negative growth.

Population Growth

It is the number of individuals added per unit population per unit time due to higher rate of births and immigration over the rate of deaths and emigration.

Let N_0 be initial population and N_t be population after a time interval, B equal to total births, I equal to immigration (individuals coming in), D equals to total deaths and E equals to emigration (individuals going out).

then, $N_t = N_0 + B + I - D - E$

Carrying Capacity/Resources

A population survives on the resources present in an area. Resources include food, water and space. **Carrying capacity** of a habitat/locality/environment is the maximum number of individuals of a population which can be provided with all the necessary resources for their healthy living. It is constant and is denoted by 'K'.

Beyond carrying capacity, the size of population begins to decrease due to lower natality, higher mortality and emigration.

Biotic Potential and Environmental Resistance

Maximum reproductive capacity or biotic potential (r) can be realised only when environmental resources are non-limiting and conditions favour minimum mortality (specific mortality).

However, environment has a limiting effect on the rise of population. The sum of abiotic (e.g., temperature, water, space) and biotic factors (e.g., food, competition, disease, predation) which checks the rise in population size and prevents the species to realise its biotic potential is called **environmental resistance.**

Environmental resistance rises as the population size approaches the carrying capacity of the habitat. It helps in limiting population size to below the carrying capacity. The effect of the environmental resistance on biotic potential is denoted by the following formula : where *r* is the reproductive rate while N is the size of population.

Abiotic Factors

Population size and population growth are influenced by duration of light, light intensity, temperature, humidity, rainfall, snow, wind and other weather conditions. Cold conditions induce hibernation and migration.

Biotic Factors

Growth rate of certain populations decreases with the increase in density (density dependent) before the carrying capacity of the environment is reached. Predators also keep the size of a population under check.

Population Fluctuation Forms

(i) **Irruptive** The population size continues to increase without any obvious reason. After reaching a peak, it decreases suddenly.

(ii) **Cyclic** There is a regular cyclic increase in population size followed by a decline due to food environmental conditions and population dynamics. Lemmings continue to increase in number in Canada and Norway for four years, after which most of them die due to disease or mass scale suicide by moving to sea and getting drowned.

Population Growth

A population can have two types of growth curves – S-shaped and J-shaped. There is an initial phase of slow growth called **lag phase**. It is followed by phase of rapid growth called **exponential growth** or **log phase**.

In S-shaped or sigmoid growth curve, there is a point of inflection whereafter growth slows down and reaches an **equilibrium** or **stagnant phase**. At this time the population size has reached the point of carrying capacity of the habitat/environment.

Population growth can be represented as a measure of carrying capacity or environmental resistance as

Here dN/dt = change in population size, r = biotic potential, N = population size, while K = carrying capacity of environment. In J-shaped growth curve, the exponential phase continues beyond the carrying capacity of the environment. Equilibrium phase does not occur. Instead a steep or sharp decline in population takes place. It is called **crash phase**.

The equation of J-shaped or exponential growth in population is as follows :

BIOTIC COMMUNITY ORGANISATION

Group of different kinds of population in the area are together known as community.

Organisms in a community inhabit a common area that has same uniform environment.

Species Composition

A number of plants, animals and other organisms occuring in a biological community, constitute species composition.

Dominants

It is the ability to influence other members of the community. A few species in a community are in abundance and stand out prominently which control the environment and determine other species.

Biotic community is named either after the dominant species (e.g., *Pinus* in pine forest, grass in grassland) or after the habitat, e.g., desert community, marine community.

Physiognomy

It is an external appearance of a community based on vertical structure and architecture of dominant species of vegetation, e.g., forest, savannah, grassland, desert.

Stratification

It is vertical layering or the phenomenon of having more than stratum formed by different plants/organisms in the same place.

A forest may have 5-7 strata – large or canopy trees, medium trees, short trees, shrubs, herbs, ground flora, etc.

Stratification is useful as it can accommodate a large number of organisms of different types and more efficient use of resources.

Species Diversity

It is an important attribute of biotic community which is determined by total number of species and their relative abudance.

Greater species diversity indicates higher number of niches and greater stability to the community.

Keystone Species

It is a species which has a significant and disproportionately large influence on the community structure and characteristics.

It has often considerably low abundance and biomoss as compared to dominant species.

Removal or decrease in number of key stone species causes serious disruption in structure and function of community.

Critical Link Species

They are species which play an important role in supporting network species as pollinators, dispersal agents, absorption or circulation of nutrients, etc. Mycorrhizal fungi help the vascular plants in obtaining inorganic nutrients from soil and organic residues, bees pollinate large number of flowers and birds disperse the seeds of number of plants.

Ecotones and Edge Effect

Ecotone is the transition zone between two communities, *e.g.,* forest and grassland. Ecotone has an admixture of species belonging to both the communities.

The increased number (and even density) of species in the region of either of the two communities.

Ecotone may be narrow or broad.

Edge effect : The increased number of species in the region of ecotone or community border is called edge effect.

ANALYSIS OF PLANT COMMUNITIES

Analytical Characters

They are structural characters which can be directly observed or measured.

Analytical characteristics if measurable are called **quantitative characters.**

Non-measurable analytical characters which can be observed are known as **qualitative characters.**

Synthetic characters are generalisations or abstractions which are derived from analytical characters.

Quantitative Characters

(i) **Frequency** : It is degree of dispersion in terms of percentage occurrence in number of sampling plots studied. There are five frequency classes :

A – (1% to 20%), B – (21% – 40%), C – (41% – 60%), D – (61% – 80%), E – (81 – 100%)

(ii) **Abudance** : It is of individuals of a species per unit area.

(iii) **Diversity** : It is the number of species per unit member (or square root) of individuals.

(iv) **Cover** : It is percentage area of ground covered by plants of a species. Area of cover is calculated by multiplying the average area of radius with .

(v) **Biomass :** It is quantity of living material per unit area.

(vi) **Leaf size :** Percentage of species having different leaf sizes indicates degree of adaptibility to the environment.

ECOLOGICAL SUCCESSION

It is the natural development of a series of biotic communities at the same time, one after the other till a climax community develops which does not change further it is in perfect harmony with the environment of the area.

A biotic or ecological community is influenced by biotic factors, physico-chemical factors and geographic factors.

Primary Succession (prisere). Biotic or ecological succession on a primary bare area like rock, outcrop or glacial moraine. It takes long time of 1000 years or more.

Secondary Succession (Subsere). Biotic succession on a secondarily bare area, *e.g* forest fire, deforestation. It takes 50–100 years (for grass land) and 100 – 200 years (for forest).

Pioneer Community : First biotic community on a bare area.

Seral Community : Transitional community appearing in an area during biotic succession.

Climax Community : Stable, self-perpetuating and final community appearing in an area at the end of biotic succession which is in perfect harmony with climate of the area - **climatic climax community.**

The various biotic communities that develop during biotic succession are called seral or transitional communities.

The entire sequence of development stages of biotic succession from pioneer to climax community is known as *sere*.

LITHOSERE (SUCCESSION ON BARE ROCK)

Lichen : Bare rock is invaded first by **crustose** lichens (*Graphis, Rhizocarpon*). They corrode the rock at places causing **foliose lichens** (*e.g., Parmelia, Dematocarpon)* to invade, eliminate crustose lichnes and creating conditions for invasion by mosses.

In tropics, blue-green algae are pioneers instead of lichens.

Moss Stage : Mosses capable of tolerating drought invade the humus rich holes created by foliose lichens, *e.g., Tortula, Grimmia, Polytrichum.*

Annual Grass Stage : Annual hardy grasses and herbs invade the humus rich moss dominated rock surface, *e.g., Aristida, Poa.*

Perennial Grass Stage : Annual grasses are slowly replaced by perennial grasses with runners and rhizomes. *e.g.,Heteropogon, Cymbopogon.*

Shrub Stages : Shurbs begin to grow in area occupied by perennial grasses. They increase soil and humus content besides moisture., *e.g. Rhus, Capparis, Zizyphus.*

Climax Community : Initially hardy, light demanding small trees invade the area. They make the habitat shadier and more moist. Ultimately, trees, shrubs and herbs representing the climax community begin to grow in the area.

HYDROSERE

Plankton Stage : Phytoplanktons (diatoms, flagellates, blue green and green algae) are the pioneers in a freshly formed water body.

Submerged stage : *Hydrilla, Potamogeton* and *Najas* form dense growth at bottom enriched with organic matter.

Floating Stage : In the shallow regions plants appear with tuberous rhizomatous and creeping stems and leaves floating on the surface of water, *e.g., Nymphaea, Nelumbo.*

Reed Swamp Stage : In shallower water, amphibian plants (with emergent leaves) begin to grow *(e.g., Sagittaria, Typha, Phragmites)*

Sedge / Marsh Meadow Stage : On newly built up shores, *Carex* (Sedge), *Juncus, Cyperus,* some grasses and herbs grow rapidly lower the water table.

Woodland Stage : Rhizome bearing shrubs and small trees capable of tolerating excessive light and water logged conditions appear on the edges of sedge/marsh meadow. Eg.: *Cornus, Populus, Alnus* etc.

Climax Stage : New trees, shrubs and herbs which are in perfect harmony with the climate of the area.

Changes in Community Characteristics During Succession

Community Structure	**Seral**	**Climax**
(i) Size of Individual	Small	Large
(ii) Niches	Few, generalised	Many specialised
(iii)Community Organisation	Simple	Complex
Community Functions		
(i) Food Chains and Food Webs	Simple	Complex
(ii) Efficiency of Energy use	Low	High
(iii) Nutrient Conservation	Low	High

Biodiversity

The term **biodiversity** refers to the totality of genes, species, and ecosystems of a region.

Biodiversity loss is now one of the world's most pressing crisis. The primary reason for the concern is the realisation that biological diversity is being lost even before its size is known.

The known and described number of species of all organisms on the earth is between 1.7 and 1.8 million.

The predicted number of total species varies from 5 to 50 million and averages at 14 million. About 61 per cent of the known species are insects. Only 4650 species of mammals are known to science. A large number of plant species (2,70,000) and vertebrates are known.

Levels of Biodiversity

Biological diversity includes three hierarchical levels :

(i) Genetic diversity

(ii) Species diversity

(iii) Community and ecosystem diversity.

Genetic Diversity

Genetic diversity refers to the variation of genes within species; the differences could be in alleles, in entire genes (the traits determining particular characteristics) or in chromosomal structures. The genetic diversity enables a population to adapt to its environment and to respond to natural selection.

The amount of genetic variation is the basis of **speciation** (evolution of new species). It has a key role in the maintenance of diversity at species and community levels. Genetic diversity of a community will be greater if there are many species.

Species Diversity

Species are distinct units of diversity. Species diversity refers to the variety of species within a region. Simplest measure of species diversity is **Species richness,** i.e., the number of species per unit area. The number of species increases with the area of the site.

In nature, both the number and kind of species, as well as the number of individuals per species vary, leading to greater diversity.

Community and Ecosystem Diversity

Diversity at the level of community and ecosystem has three perspectives. **Alpha diversity** (within-community diversity), **Beta diversity** (between-community diversity). Diversity of the habitats over the total landscape or geographical area is called **Gamma diversity.**

Ecosystem diversity describes the number of niches, trophic levels and various ecological processes that sustain energy flow.

In India, we are endowed with a rich diversity of the biogeograpically distinct regions due to varying conditions and species groupings.

Biogeographical regions of India are:

1. Trans Himalaya
2. Himalaya
3. Desert
4. Semi arid
5. Western Ghats
6. Deccan Peninsula
7. Gangetic Plain
8. Coasts
9. North East
10. Islands

Deccan Peninsula has the most extensive coverage of the Indian landmass - 42 percent

About 33% flowering plants recorded in India are endemic to our country.

10% mammalian fauna are endemic to India

DEGREE OF BIODIVERSITY (REICE - 1994)

The degree of biodiversity increases with perturbation and heterogeneity.

GRARDIENTS OF BIODIVERSITY

Biodiversity varies with change in latitude or altitude. Biodiversity increases, when we move from high to low latitude.

The favourable environmental conditions favour speciation, and make it possible for a large number of species to grow.

Tropical regions are rich in biodiversrity.

BENEFITS OF BIODIVERSITY

(i) Food and fabrics are provided

(ii) Ecological balance is maintained

(iii) Economic benefits are provided by preserving biodiversity (pest resistant crops, medicines, ecotourism)

(iv) Biodiversity enriches the lives of people in industrialized world.

THREATS TO BIODIVERSITY

Important factors leading to extinction of species and consequent loss of biodiversity are

Habitat Loss and Fragmentation

The distruction of habitats is the primary reason for the loss of biodiversity. When people cut down trees, fill a wetland, natural habitat of a species is changed or destroyed.

Over exploitation of a particular species reduces to an extent that it becomes valunerable to extinction.

Disturbance and Pollution

Man, by using fire more frequently may change species richness of community.

Pollution may reduce and eliminate populations of sensitive species. For example, pesticide linked decline of fish-eating birds and falcons. Lead poisoning is another major cause of mortality of many species. Water bodies drastically reduce species diversity.

Over exploitation of species

Intensive agriculture

Forestry

Introduction of Exotic Species

New species entering a grographical region are called exotic or alien species. Introduction of such invasive species may cause disapperance of native species through changed biotic interactions.

Nile perch, an exotic predatory fish introduced into lake Victoria threatens the entire ecosystem of the lake by eliminating several native species of the small Cichlid fish species.

Water hyacinth clogs rivers and lakes and threatens the survival of many aquatic species in lakes and river flood plains in several tropical countries, including India.

EXTINCTION OF WILD SPECIES

Type of extinction : Species become extinct through three types of processes.

(i) **Natural extinction :** Due to change in environmental conditions. (Also called background extinction)

(ii) **Mass extinction :** Due to catastrophe.

(iii) **Anthropogenic extinction :** Due to human activities like hunting, settlements, over exploitation and habitat destruction.

Large number of plants and animals have become extinct during the past 10,000 years. The various reasons for this state are as follows –

(i) **Hunting** : Hunting or killing of wild animals is of three types –**subsistence hunting** for food and safety, **sport hunting** for recreation and **commercial hunting** for obtaining a commodity like musk, ivory or fur.

(ii) **Destruction of Habitats** : Use of fire for hunting by the primitive man destroyed a large number of habitats of wild life.

(iii) **Dams and Reservoirs.** They are large impoundments of water which submerge natural habitats of several species of wild life bringing about extinction of some and decrease in population of others.

(iv) **Pollution.** Acid rain kills both terrestrial and aquatic life. Water pollution harms aquatic animals and plants.

(v) **Highways.** They disturb wild life. Some of the animals are killed by passing vehicles.

(vi) **Cleanliness.** Carcases are being burnt or buried in order to reduce stench. This has caused decline in the population of **California Condor** (*Gymnogyps californianus)*, a scavanger bird.

(vii) **Migratory Routes.** Physical alterations are going on everywhere. Changes in route and settling areas of migratory animals may result in their going astray and getting killed.

(viii) **Ignorance.** Most persons are ignorant about the intricate relationships present in wild life and the importance of maintaining wild life.

(ix) **Over-Exploitation.** Excessive hunting, overgrazing, excessive felling and overfishing are resulting in depletion of a number of species of wild life.

(x) **Trade.** Some articles from wild life are highly priced and are always in demand, e.g., exotic meat, ivory, fur, musk.

(xi) **Introduction of Exotic Species.** Exotic species disturb the web of relationships amongst the organisms of a place.

CONCEPT OF THREATENED SPECIES

Threatened species (T) are those species which are likely to become extinct if immediate steps are not taken to ensure that they have proper food, proper habitat, protection from predators, and exotic species so that they are able to realise their biotic potential.

A record of threatened species of plants and animals is maintained by **International Union for Conservation of Nature and Natural Resources (IUCN),** Morges, Switzerland. It is called **Red Data Book.**

Species are classified by the IUCN Red List into nine groups,[15] set through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation.

- Extinct (EX) – No known individuals remaining.
- Extinct in the Wild(EW) – Known only to survive in captivity, or as a naturalized population outside its historic range.
- Critically Endangered (CR) – Extremely high risk of extinction in the wild.
- Endangered (EN) – High risk of extinction in the wild.
- Vulnerable (VU) – High risk of endangerment in the wild.
- Near Threatened (NT) – Likely to become endangered in the near future.
- Least Concern (LC) – Lowest risk. Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category.
- Data Deficient (DD) – Not enough data to make an assessment of its risk of extinction.
- Not Evaluated (NE) – Has not yet been evaluated against the criteria.

When discussing the IUCN Red List, the official term "threatened" is a grouping of three categories: Critically Endangered, Endangered, and Vulnerable.

The Red List of 2012 was released 19 July 2012 at Rio+20 Earth Summit; nearly 2,000 species were added, with 4 species to the extinct list, 2 to the rediscovered list. The IUCN assessed a total of 63,837 species which revealed 19,817 are threatened with extinction. With 3,947 described as "critically endangered" and 5,766 as "endangered", while more than 10,000 species are listed as "vulnerable". At threat are 41% of amphibian species, 33% of reef-building corals, 30% of conifers, 25% of mammals, and 13% of birds. The IUCN Red List has listed 132 species of plants and animals from India as "Critically Endangered".

Endangered Species (E)

They are those threatened species or taxa which are in danger of extinction if the current causal factors continue to operate.

Examples: Lion Tailed Macaque - *Macaca silenus*
Asiatic Wild Ass - *Asinus hemionus khur*

Vulnerable Species (V)

Vulnerable species or taxa have sufficient population at present but the same is depleting fast (hence **depleted species**) so that they are likely to enter the category of endangered species if the factors bringing about depletion are allowed to continue

Examples: Golden Langur - *Presbytis geeri*
Leopard Cat - *Felix bengalensis*

Rare Species (R)

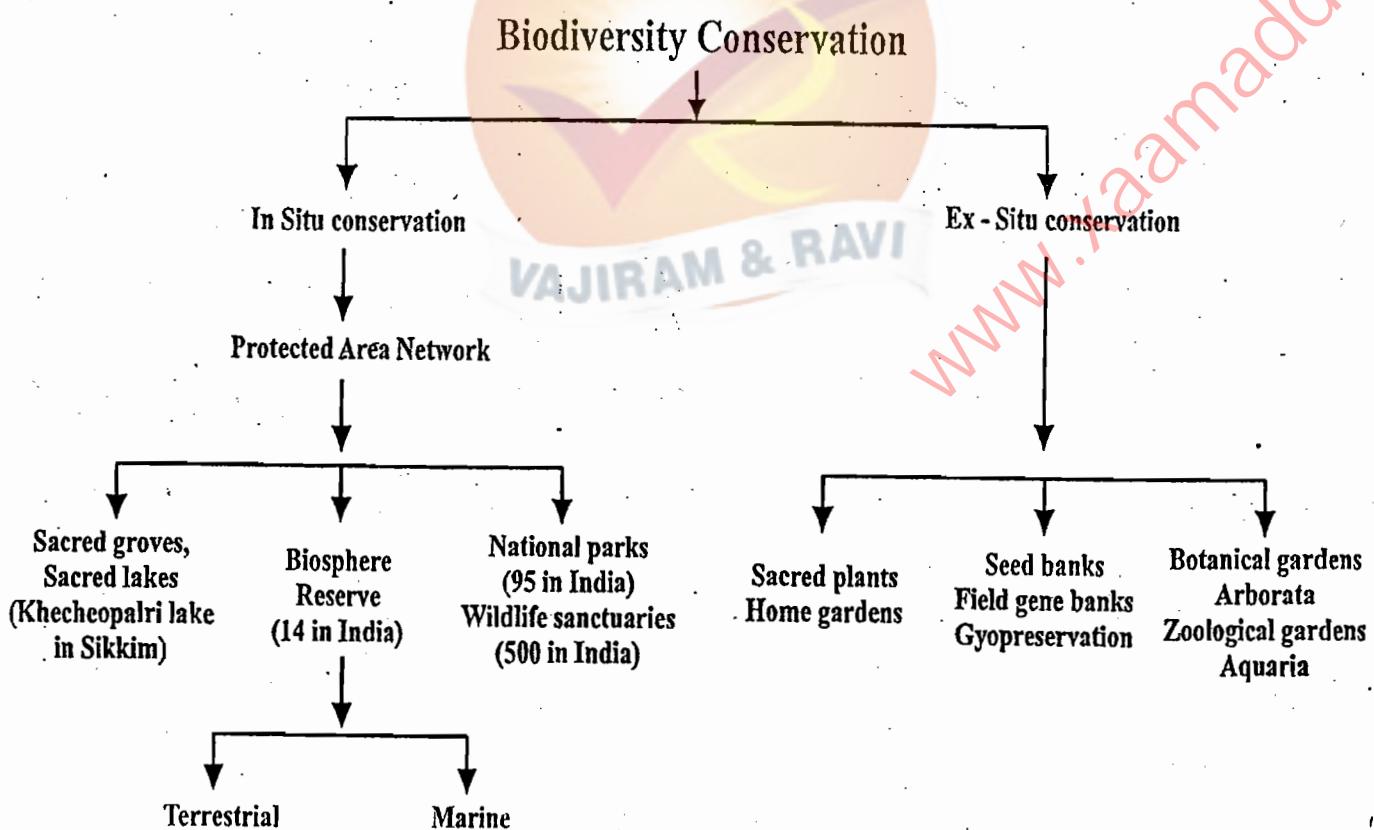
The populations of species or taxa are small, either localised or thinly scattered.

Example: Hawaiian Monk Seal - *Monochus schauinslandii*
Snow Loris - *Nycticebus corcong*

Status of Threatened Species

The 2000 Red List contains assessments of more than 18,000 species, 11,046 of which are listed as critically Endangered. According to the Red List, in India, 44 plants species are critically endangered, 113 endangered and 87 vulnerable. Amongst animals, 18 are critically endangered, 54 endangered and 143 vulnerable.

Pigmy hog, Red Panda and Black buck are examples of threatened animals in India.

Curpressus cashmeriana is vulnerable species in India.

CONSERVATION OF WILD LIFE

Conservation of wild life is the scientific management of wild life in such a way that it remains at the optimum level, yielding greatest sustainable benefit to the present generation while retaining its potential to meet the needs and aspirations of future generations.

World Conservation Strategy for wild life was formulated in 1980 by scientists from 100 countries. The important measures are as follows :

1. **Nondisturbance.** Wild life should be disturbed to the minimum and that also when it is essential.

2. **Threatened Species.** The threatened species should be protected on priority basis as compared to non-threatened species and taxa.
3. **Monotypic Forms.** Priority for conservation should be given to those species which are lone representatives of their genera and families.
4. **Priority Amongst Threatened Species.** In conservation, an endangered species is given preference over vulnerable one and vulnerable species over rare species.
5. **In Situ and Ex-situ Conservation.** Threatened species are protected both in their natural habitats as well as in man-made habitat of zoos, botanical gardens and arboureta conservation.
6. **Useful Organisms.** All varieties of currently useful organisms like food crops, forage plants, timber plants, livestock and animals for aquaculture should be conserved.
7. **Wild Relatives.** Wild relatives of economically useful organisms should be identified and preserved.
8. **Habitats.** The habitats of the wild relatives of valuable and useful organisms are identified and preserved in protected areas.
9. **Ecosystem versus Species.** The whole ecosystem should be preserved rather than a single species.
10. **National Parks and Sanctuaries.** They should be established to provide protection to habitats and ecosystems of wild life.
11. **Migratory Animals.** The routes of migratory animals should not be disturbed at least in the area of their stoppage and rest.
12. **Exploitation.** Productive capacity of useful species and ecosystems, should be determined.

Protected Areas

They are specific biogeographical areas where wild life is protected from habitat destruction, exploitation, hunting and poaching. e.g., desert, temperate forest (Himalayas), tropical rain forest (Andamans), lakes.

National Parks. They are areas reserved for wild life where the latter is able to obtain all the required natural resources and proper habitats. At present India has 99 national parks (66 in 1988) occupying more than 1% area of the country.

Sanctuaries. They are tracts of land with or without a lake where animals are protected from all types of exploitation and habitat disturbance. Presently India has 492 sanctuaries occupying over 3.2% of the area.

Biosphere Reserves. They are large tracts of protected land with multiple use preserving the genetic diversity of representative ecosystem by protecting wild life, traditional life styles of the tribals and varied plant and animal genetic resources.

They have been set up under MAB program of UNESCO. A total of 408 biosphere reserves are to be set up in 94 countries.

Each biosphere reserve has (i) **Core Zone**, No human activity is permitted, (ii) **Buffer Zone.** Limited human activity is allowed. (iii) **Manipulation Zone.** All types of human activities which do not disturb ecology are allowed.

NATIONAL PARKS, SANCTURIES AND BIORESERVES

Sr. No.	NATIONAL PARK	SANCTURY	BIORESERVES
1.	These are maintained by government and protected / conserved for betterment of wild life	These are segment of land where animal can take refuge without being hunted	They are multipurpose conserved/protected areas which are meant for preserving the biodiversity.
2.	Cultivation, grazing, forestry and habitat manipulation are not allowed	Many activities like collection, private ownership of land are allowed	Except the buffer zone, no biotic interference
3.	Tourism permissible	Tourism permissible	Tourism normally not permissible
4.	Research and scientific management lacking	Research and scientific management lacking	Research and scientific management takes place
5	So far no attention to genepools and conservation	So far no attention	Attention given

Biosphere reserves of India (area wise)

	Year	Name	State	Type	Key Fauna	Area (km²)
1	2008	Great Rann of Kutch	Gujarat	Desert	Indian Wild Ass	12454
2	1989	Gulf of Mannar	Tamil Nadu	Coasts	Dugongor Sea Cow	10500
3	1989	Sundarbans	West Bengal	Gangetic Delta	Royal Bengal Tiger	9630
4	2009	Cold Desert	Himachal Pradesh	Western Himalayas	Snow Leopard	7770
5	1988	Nandadevi	Uttarakhand	Western Himalayas		5860
6	1986	Nilgiri Biosphere Reserve	Tamil Nadu,Kerala a ndKarnataka	Western Ghats	Nilgiri Tahr,Lion-tailed macaque	5520
7	1998	Dihang-Dibang	Arunachal Pradesh	Eastern Himalaya		5112
8	1999	Pachmarhi Biosphere Reserve	Madhya Pradesh	Semi-Arid	Giant Squirrel,Flying Squirrel	4981.72
9	2010	Seshachalam Hills	Andhra Pradesh	Eastern Ghats		4755
10	1994	Simlipal	Odisha	Deccan Peninsula	Gaur,Royal Bengal Tiger, Wild elephant	4374
11	2005	Achanakamar - Amarkantak	Madhya Pradesh,Chhat tisgarh	Maikala Range		3835
12	1989	Manas	Assam	East Himalayas	Golden Langur,Red Panda	2837
13	2000	Khangchendzonga	Sikkim	East Himalayas	Snow Leopard,Red Panda	2620
14	2001	Agasthyamalai Biosphere Reserve	Kerala,Tamil Nadu	Western ghats	Nilgiri Tahr,Elephants	1828
15	1989	Great Nicobar Biosphere Reserve	Andaman and Nicobar Islands	Islands	Saltwater Crocodile	885

Biosphere reserves of India (area wise)

	Year	Name	State	Type	Key Fauna	Area (km²)
16	1988	Nokrek	Meghalaya	East Himalayas	Red Panda	820
17	1997	Dibru-Saikhowa	Assam	East Himalayas	Golden Langur	765
18	2011	Panna	Madhya Pradesh	catchment area of the Ken River	tiger, chital, chinkara, sambhar and sloth bear	543

IMPORTANT WILD LIFE PROJECTS OF INDIA

Project Tiger (*Panthera tigris*). The project was started in 1973 in order to check depletion in population of tiger. Initially it was undertaken in 17 national parks. But recently the projects has been extended to 6 more national parks (a total of 23). Important National Parks associated with Project Tiger and Corbett National Park, Nainital (U.P.), Sunderbans Tiger Reserve, 24 Parganas (W.Bengal) and Ranthambore National Park, Savai Madhopur (Rajasthan)

Lion Project *(Panthera leo persies*). The project was started in 1972. It is located in Gir National Park, Junagarh (Gujarat).
Snow Leopard Project (Panthere uncia). Khangchendzonga National Park (Gangtok).
Rhino Project (*Rhinoceros unicornis)*. The project was started in 1987. The important sanctuaries and parks where the project has been undertaken are Kaziranga National Park, Sibsagar, Jorhat (Assam) and Manas Sanctuary, Barpeta (Assam).
Kashmir Stag or Hangul Project *(Cervus elephus hanglu)*. It was one of the earliest projects for conservation of wild life. The project is going on in Dachigam Sanctury Srinagar (J.K.) since 1970.
Lion Tailed Macaque Project (*Macaca silenus)*. Annamalai Sanctuary (T.N) and Silent Valley National Park (Kerala).
Great Indian Bustard Project *(Ardeotis nigriceps)*. Desert National Park Jaiselmer (Raj.) and Great Indian Bustard Sanctuary (Maharashtra)
Indian Crocodile Project *(Crocodilus palustris, C. porosus)* Bhitar Kanika Sanctuary, Cuttack (Orissa), Nagarjuna Sanctuary, Guntur (A.P.)
River Dolphin Project *(Platinisia gangetica)* Vikramshila (Bihar).
Musk Dur Project (*Koschul moschiferus)* Kedarnat Sanctuary (U.P)

Convention on Biological Diversity

The Earth's biological resources are vital to humanity's economic and social development. As a result, there is a growing recognition that biological diversity is a global asset of tremendous value to present and future generations. At the same time, the threat to species and ecosystems has never been so great as it is today. Species extinction caused by human activities continues at an alarming rate.
In response, the United Nations Environment Programme (UNEP) convened the Ad Hoc Working Group of Experts on Biological Diversity in November 1988 to explore the need for an. international convention on biological diversity. Soon after, in May 1989, it established the Ad Hoc Working Group of Technical and Legal Experts to prepare an international legal instrument for the conservation and sustainable use of biological diversity. The experts were to take into account "the need to share costs and benefits between developed and developing countries" as well as "ways and means to support innovation by local people".
By February 1991, the Ad Hoc Working Group had become known as the Intergovernmental Negotiating Committee. Its work culminated on 22 May 1992 with the Nairobi Conference for the Adoption of the Agreed Text of the Convention on Biological Diversity.
The Convention was opened for signature on 5 June 1992 at the United Nations Conference on Environment and Development (the Rio "Earth Summit"). It remained open for signature until 4 June 1993, by which time it had received 168 signatures. The Convention entered into force on 29 December 1993, which was 90 days after the 30th ratification. The first session of the Conference of the Parties was scheduled for 28 November – 9 December 1994 in the Bahamas.
The Convention on Biological Diversity was inspired by the world community's growing commitment to sustainable development. It represents a dramatic step forward in the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources.

The ***Cartagena Protocol on Biosafety to the Convention on Biological Diversity*** is an international treaty governing the movements of living modified organisms (LMOs) resulting from modern biotechnology from one country to another. It was adopted on 29 January 2000 as a supplementary agreement to the Convention on Biological Diversity and entered into force on 11 September 2003. The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes anadvance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol contains reference to a precautionary approach and reaffirms the precaution language in Principle 15 of the Rio Declaration on Environment and Development. The Protocol also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

The ***Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity*** is an international agreement which aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by

appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components. It was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting on 29 October 2010 in Nagoya, Japan. The Nagoya Protocol will enter into force 90 days after the date of deposit of the fiftieth instrument of ratification. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources is one of the three objectives of the Convention on Biological Diversity.

The National Biodiversity Authority (NBA) was established in 2003 to implement India's Biological Diversity Act (2002). The NBA is Autonomous body and that performs facilitative, regulatory and advisory function for Government of India on issue of Conservation, sustainable use of biological resource and fair equitable sharing of benefits of use.
The Biological diversity Act (2002) mandates implementation of the act through decentralized system with the NBA focusing on advice the Central Government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of the utilization of biological resources; advice the State Government in the selection of areas of biodiversity importance to be notified under sub-section (1) of section 37 as heritage sites and measures for the management of such heritage sites;
The state Biodiversity Board (SBBs) focusing on advice the State Government, subject to any guidelines issued by the Central Government, on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources;
Regulate by granting of approvals or otherwise request for commercial utilization or bio-survey and bio-utilization of any biological resource by Indians; and Local Level Biodiversity Management committees (BMCs) responsible for promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivators, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity.
The NBA with its Headquarters in Chennai, India delivers its mandate through a structure that comprises of the Authority, secretariat, SBBs, BMCs and Expert Committees.
Since its establishment, NBA has supported creation of SBBs in 28 States, facilitated establishment of around 32,131 BMCs, advised notification.

General functions of the Authority :-
The Authority may perform the following functions; namely :-

- lay down the procedure and guidelines to govern the activities provided under sections 3, 4 and 6 ;
- advise the Central Government on any matter concerning conservation of bio-diversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the use of biological resource and knowledge;
- coordinate the activities of the State Bio-diversity Boards;
- provide technical assistance and guidance to the State Bio-diversity Boards;
- commission studies and sponsor investigations and research;
- engage consultants, for a specific period, not exceeding three years, for providing technical assistance to the Authority in the effective discharge of its functions:

Provided that if it is necessary and expedient to engage any consultant beyond the period of three years, the Authority shall seek prior approval of the Central Government for such an engagement

- collect, compile and publish technical and statistical data, manuals, codes or guides relating to conservation of biodiversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the use of biological resource and knowledge;
- organise through mass media a comprehensive programme regarding conservation of biodiversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the use of biological resource and knowledge.
- plan and organise training of personnel engaged or likely to be engaged in programmes for the conservation of biodiversity and sustainable use of its components;
- prepare the annual Budget of the Authority incorporating its own receipts as also the devaluation from the Central Government provided that the allocation by the Central Government shall be operated in accordance with the budget provisions approved by the Central Government;
- recommend creation of posts to the Central Government, for effective discharge of the functions by the Authority and to create such posts, provided that no such post whether permanent/ temporary or of any nature, would be created without prior approval of the Central Government;
- approve the method of recruitment to the officers and servants of the Authority;
- take steps to build up data base and to create information and documentation system for biological resources and associated traditional knowledge through biodiversity registers and electronic data bases, to ensure effective management, promotion and sustainable uses;
- give directions to State Biodiversity Boards and the Biodiversity Management Committees in writing for effective implementation of the Act ;
- report to the Central Government about the functioning of the Authority and implementation of the Act ;
- recommend, modify, collection of benefit sharing fee under sub section (1) of Section 6 or Changes of royalties under sub-section (2) of section 19 in respect of biological resources from time to time ;
- sanction grants-in-aid and grants to the State Biodiversity Board and Bio -diversity Management Committees for specific purposes;
undertake physical inspection of any area in connection with the implementation of the Act ;
- take necessary measures including appointment of legal experts to oppose grant of intellectual property right in any country outside India on any biological resource and associated knowledge obtained from India in an illegal manner;
- do such other functions as may be assigned or directed by the Central Government from time to time.

Biodiversity related Legal Frameworks in India

SL. NO.	LEGAL ACTS
1	Fisheries Act, 1897
2	Destructive Insects and Pests Act, 1914
3	The Indian Forest Act, 1927
4	Agricultural Produce (Grading and Marketing) Act, 1937
5	Indian Coffee Act, 1942
6	Import and Export (Control) Act, 1947
7	Rubber (Production and Marketing) Act, 1947
8	Tea Act, 1953
9	Mining and Mineral Development (Regulation) Act 1957
10	Prevention of Cruelty to Animal Act, 1960
11	Customs Act, 1962
12	Spices Board Act, 1986
13	Seeds Act, 1966
14	The Patents Act, 1970
15	Wildlife (Protection) Act, 1972
16	Marine Products Export Development Authority Act 1972
17	Water (Prevention and Control of Pollution) Act, 1974
18	Tobacco Board Act, 1975
19	Territorial Water, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976
20	Water (Prevention and Control of Pollution) Cess Act, 1977
21	Maritime zones of India (Regulation and fishing by Foreign Vessels) Act 1980
22	Forest (Conservation) Act, 1980
23	Air (Prevention and control of Pollution) Act 1981
24	Agricultural and Processed Food Products Export Development Authority Act 1985/1986
25	Environment (Protection) Act, 1986
26	Species Act, 1986
27	National Diary Development Board, 1987
28	Rules for the manufacture, use/import/export and storage of hazardous microorganism/genetically engineered organisms or cells, 1989
29	Foreign Trade (Development and Regulation) Act, 1992
30	Protection of Plant varieties and Farmer's Rights (PPVFR) Act, 2001
31	Biological Diversity Act, 2002
32	Plant Quaratine (Regulation of Import into India) order 2003
33	Biological Diversity Rules, 2004
34	The Food Safety and Standards Act, 2006
35	Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006
36	National Green Tribunal Act 2010

THREATENED ANIMALS OF INDIA

T = Threatened, R = Rare; E=Endangered; V=Vulnerable

MAMMALS

No.	Species	Status
1.	Macaca silenus (L.) – Lion-Tailed Macaque.	E
2.	Loris tardigradus (L.) - Slender Loris	T
3.	Hylobates hoolock(Harlan)- Hoolock Gibbon	E
4.	Panthera tigris (L.) - Tiger	T
5.	Panthera leo persica (Meyer)- Asiatic Lion	T
6.	Panthera Pardus (L.) Leopard or Panther	T
7.	Felis bengalensis Kerr Leopard Cat	V
8.	Felis temmincki :V and Horsfield Golden Cat	E
9.	Felis manual Pallas - Pallas's Cat	R
10.	Felis silverstris ornata Gray- Indian Desert Cat	R,E
11.	Canis lupus (L.) Wolf	E
12.	Vulpes bengalensis (shaw) Indian Fox	T
13.	Ailurus fulgens F.Cuvier- Red Panda	E
14.	Manis crassicaudata Gray- The Indian Pangolin	T
15.	Elephas maximum (L.) Asian Elephant	E
16.	Rhinoceros unicornis (L.)- The great one-horned Rhinoceros	E
17.	Asinus hemionus khur (Lesson)- Asiatic wild ass	E
18.	Bos mutus (Przewalski)- Wild Yak	R
19.	Bubalus bubalis (L.) wild Buffalo	E
20.	Cervus elaphus hanglu Wagner Hangul or Kashmir Stag	E
21.	Antelope cervicarpra (L.) Black buck	V
22.	Moschus moschiferus L.- Musk Deer	E
23.	Gazella dorcas (L.) Chinkara	V

BIRDS

No.	Species	Status
1.	Choriotis nigriceps (Vigors) Great Indian Bustard	E
2.	Grus leucogeranus Pallas- Siberian Crane	T
3.	Grus nigricollis Przeyalski- Blacknecked Crane	E

REPTILES

No.	Species	Status
1.	Chelonia mydas (L.) - Green Sea Turtle	T
2.	Gavialis gangeticus (Gmelin)- Gharial	R,T
3.	Crocodylus porosus Schneider- Estuarine Crocodile	T
4.	Crocodylus palustris (Lesson)- Mugger	T
5.	Varanus bengalensis (Daudin)- Common Indian Monitor	E
6.	Varanus griseus (Dudin)- Indian Desert Monitor	T
7.	Python molurus(L.) - Indian Rock Python	E
8.	Python reticulatus (Schneider)- Reticulated Python	E

AMPHIBIANS

No.	Species	Status
1.	Tylototriton verrucosus Anderson- Himalyan Newt	R

Name & Location	Area in Sq. Km.	IMPORTANT ANIMALS FOUND
1. Kaziranga National Park District Sibsagar(Assam)	430	**Rhinoceros**, elephant, wild buffalo, bison, tiger, leopard, sloth, bear, sambhar, swamp deer, barking deer, wild bear, gibbon, python and birds like pelican, stork and ring-tailed fishing eagles. This is a famous National Park of famous one-horned rhinoceros of India.
2. Sundarbans(Tiger Reserve) 24-Pargana(West Bengal)	2585	**Tiger**, wild boar, deer, gangetic dolphin, estuarine crocodile.
3. Hazaribagh National Park Hazaribagh Jharkhand	186	**Tiger**, leopard, hyaena, wild bear, gaur, sambhar, nilgai, chital, sloth, bear, peafowl
4. Corbett National Park District Nainital (Uttaranchal)	525	**Tiger**, elephant, panther, sloth bear, wild bear, nilgai, sambhar, chital, crocodile, python, king cobra, peafowl, partridge. This is the first National Park of India which is famous for tigers.
5. Gir National Park District Junagarh (Gujarat)	1412	**Asiatic lion**, panther, stripped hyaena, sambhar, nilgai, chital, 4-horned antelope, chinkara, wild bear, langur, python, crocodile, green pigeon, partridge. This National park is famous for the Asiatic lions.
6. Kanha National Park Mandia and Balaghat (M.P.)	940	**Tiger, panther, chital, chinkara**, barking deer, blue bull, **four horned deer**, langur, wild bear, black buck, nilgai, wild dog, sloth bear, sambhar, crocodile, grey horn bill, egret, pea-fowl.
7. Tandoba National Park Chandrapur (Maharashtra)	116	**Tiger** sambhar, sloth bear, bison, chital, chinkara, barking deer, blue bull, four horned deer, langur, pea-fowl, crocodile.
8. Bandipur National Park District Mysore (Karnataka)	874	**Elephant, tiger, leopard**, sloth bear, wild dog, chital, panther, barking deer, langur, porcupine, gaur, sambhar, malabar squirrel, green pigeon.
9. Desert National Park Jaisalmer (Rajasthan)	3000	**Great Indian Bustard, Black buck**, chinkara.

SOME IMPORTANT SANCUTARIES OF INDIA

Name & Location	Area in sq. km.	Important Animals
1. Keoladeo Ghana Bird Sanctuary Bharatpur (Rajasthan) Famous for birds	29	**Siberian crane**, egrets, herons spoon bill etc.
2. Annamalai Sanctuary Coimbatore (Tamil Nadu)	958	**Tiger, elephant**, gaur, spotted deer, wild dog, sloth bear, sambhar, panther.
3. Jaldapara Sanctuary Madarihat (West Bengal)	1155	**Rhino, elephant, tiger**, leopard, deer, sambhar and different kinds of birds.
4. Sultanpur Lake Bird Sanctuary Gurgaon (Haryana)	12	**Crane, sarus, spotbill, duck, drake, green pigeon**, wild bear, crocodile, python.
5. Bir Moti Bagh Wildlife Sanctuary Patiala (Punjab)	8.3	Nilgai, **wild boar, hog deer**, black buck, blue bull, jackal, peafowl, partridge, sparrow, myna, pigeon, dove.
6. Shikari Devi Sanctuary Mandi (Himachal Pradesh)	213	**Black bear, snow leopard**, **flying fox**, barking deer, musk deer, chakor, partridge.
7. Dachigam Sanctuary Srinagar (Jammu & Kashmir)	89	**Hangul or Kashmir stag, musk deer**, snow leopard, black bear, brown bear.
8. Mudumalai Wildlife Sanctuary Nilgiri (Tamil Nadu)	520	**Elephant, gaur, sambhar, chital, barking deer**, mouse deer, **four horned antelope**, langur, giant squirrel, flying squirrel, wild dog, wild cat, civet, sloth bear, porcupine, python, rat snake, monitor lizard, flying lizard.
9. Nagarjuna Sagar Sanctuary Guntur Karnool and Nalgonda (Andhra Pradesh)	3,568	**Tiger, panther**, wild bear, chital, nilgai, sambhar, black buck, fox, jackal, wolf, crocodile.
10. Periyar Sanctuary (Kerala)	777	**Elephants**, gaur, **leopard**, sloth bear, sambhar, bison, black langur, **hornbill**, egret. It is famous for elephants.
11. Chilka Lake Bird Sanctuary Balagaon (Orissa) (Largest brackish water lagoon in Asia)	900	An oasis of bir is like **water fowls, ducks, cranes**, Golden plovers, sand pipers, flamingoes.
12. Manas Wildlife Sanctuary Kamrup (Assam)		**Tiger, panther**, rhino, gaur, wild buffalo, sambhar, swamp deer, golden langur, wild dog wild bear.

India's Famous Tiger Reserve –

- Jim Corbett National Park – Nainital (Uttaranchal)
- Dudhwa National Park – Lakhimpur Kheri (U.P.)
- Kanha National Park – Mandala and Balghat (Madhya Pradesh)
- Indrawati National Park – (Chattishgarh)
- Simli National Park – (Orissa)

Some Special Animals –

- **Asiatic wild ass – (Endangered)** – Found in runn of Kutch and Pakistan
- **Red Panda – (Endangered)** – Found in Kanchanjunga (Sikkim)
- **Hangul-Kashmir Stag (Endangered)**–Found in Dachigam (Sri-Nagar – Jammu & Kashmir)
- **Siberian Crane – (Endangered) –** Found in Keoladeo (Ghana) National Park

The Great Indian Bustard is a huge ground bird with a long neck and long bare legs. It is an inhabitant of the semi-arid areas of Rajasthan, Gujarat and Maharashtra.Hunting for its flesh has reduced its population to over 800. It is a highly endangered bird.

"Ex-situ conservation" is the protection of wild life in zoos and botanical gardens. Other e.g., of Ex-situ conservation are gene banks, germ plasm bank, seed bank. **"In situ conservation"** is the protection of species (wild life) in their natural habitat or National parks.

1. **The world's first National Park (America) –** Yellow stone National Park
2. **India's first National Park –** Jim Corbett National Park – Nainital (Uttaranchal)
3. **Smallest tiger reserve in India –** Ranthambore National Park - Sawaimadhopur (Rajasthan). It is famous for Asiatic wild ass
4. **Largest Tiger reserve in India –** Nagarjuna Sagar Saisailum Sanctuary - Guntoor - Andhra Pradesh.
5. **Nandan-Kanan zoo is known for -** White tiger.

   Note : Sunderbans [W.Bengal] is also famous for tigers.
6. **Periyar wild life Sanctuary (Kerala) –** Famous for elephant & others.
7. **Valley of flower National park –** It is situated at Chamoli- Garhwal (Uttaranchal)
8. **Flamingoes** are protected in Chilka lake Balagaon (Orissa)
9. **Rachel carson written a book "Silent Spring"** – concerned with awareness about "Nature conservation and Environment" -1962.

   Note : In it was mentioned the effect of DDT on birds. The population of Lady bird bettle declined.
10. **The black buck** is one of the most graceful antelopes native of India. The male possesses a pair of spirally twisted horns. Once abundant in several parts of India, its population had come down until the enforcement of the wild life(Protection) Act.

SOME IMPORTANT INFORMATIONS

1. (i) National Forest Policy revised in – 1988.
   (ii) Biodiversity act of India was passed by the Parliament in the year-2002
   (iii) Forest Act–1927.
   (iv) Biosphere Reserve Scheme– 1986

2. **Wild life protection act 1972 (Revised in 1991) :**

   Objectives :

   (1) Restriction and prohibition on hunting of animals.

   (2) Protection of specified plants.

   (3) Setting up and managing **Sanctuaries** and National parks.

   (4) Empowering zoo authority.

   (5) Control of trade and commerce of wildlife.

3. **Chipko Movement** was born in March-1973 at Gopeshwar in Chamoli district. The movement had two leaders- Sundarlal Bahuguna of Silyara in Tehri and Chandi Prasad Bhatt of Gopeshwar.

   Appiko Movement – Similar type movement Appiko movement was under taken by Poundurang hegde in south in 1983.

SPECIAL WILDLIFE PROJECTS IN INDIA

Project tiger - Running since 1 April 1973 - Central Government.

The Gir Lion Sanctuary Project - Running since 1972-Central Govt. and Gujrat Govt.

Himalayan Musk Deer Project - U.P. Govt. IUCN and Central Govt.

The Manipur Brow-Antlered Deer Project- Running since 1977

Project Hangul - Since 1970 - J.& K. Govt. IUCN, WWF.

Crocodile Breeding Project - Since 1975 UNDP, Central Govt.

Project Elephant - Recently started.

ABOUT WILDLIFE

- **Red Data Book** :- This book contains a record of **animals & plants** which are known to be in danger. This Book is maintained by the **IUCN** [International Union of Conservation of Nature and Natural Resources].

- **Green Data book** :- A book containing a list of **rare plants** in a protected area like Botanical gardens.

- **Silent Valley** :- It is tropical evergreen forest in Kerela (Palghat) declared as National Reserve Forest. It is called silent valley because there is no noise in the forest during night, even that of cicadas, as they are not found there. **It is related to conservation of forest.**

- **Butterfly Park** :- India's first and only butterfly park was established in 1992 near Gangtok **(Sikkim).**

SOME OTHER INFORMATIONS ABOUT BIODIVERSITY

1. **Sacred forest :** These are forest patches protected by tribal communities due to religious sanctity in Karnataka, Maharashtra, Kerela, Meghalaya.

   Sacred lake : Khecheopalri lake in Sikkim has been declared "Sacred lake" by people.

2. **Mine Spoil :**

   The land that has been destroyed due to mining is known as **derelict land** or **mine spoil.**

3. **Hot Spot :**

   Norman Myers developed the hot spot concept in 1988. This is a mega diversity zone. Where large number of species are found. It is an area of the richest and the most threatened reservoirs of plant and animal life on the earth. Initially 25 biodiversity hot spots were identified in world, now number of biodiversity hot spot in the world are 34 out of these 3 hotspots are found in India.

   (i) Western Ghats and Sri Lanka **(ii) Indo-Burma** **(iii) The Himalayas**

   Note :

   - Hot spot covers the 1.4% of the earths land area.
   - The key criteria for determining a hot spot are :
     1. Number of endemic species
     2. Degree of threat

4. **Biodiversity :-** The term biodiversity refers to the totality of genes, species and ecosystem of a region.

   - **Species diversity :** Variety of species within a region.
   - **Species richness :** The number of species in per unit area.
   - If species evenness or equitability is high in an area than it will be considered more diverse.

5. **Diversity at the level of community – Three types :**

   (i) **Alpha diversity :** Diversity with in community.

   (ii) **Beta diversity :** Diversity between community.

   (iii) **Gamma diversity :** Diversity of the habitats over the total landscape or geographical area.

6. **Reason for loss of Biodiversity :**

   (i) Habitat loss and fragmentation. (ii) Disturbance and pollution.

   (iii) Introduction of exotic species – New species entering in a geographical region it is called exotic speacies or alien species. Such species may cause disappearance of native species through changed biotic interactions. Exotic species are having large impact especially in island ecosystem.

   e.g. of exotic species :

   - Nile perch (Predatory fish introduced into lake victoria, (East Africa) – Responsible for extinction of cichlid fish.
   - Water *hyacinth* (Eicchornia)
   - *Lantana camara*
   - *African cat fish (Clarias gariepinus)* – Respponsible for extinction of indian cat fish.

7. **Type of Extinction of species :**

   (i) Natural extinction : Due to change in environmental condition.

   (ii) Mass extinction : Due to catastrophs.

   (iii) Anthropogenic extinction : Due to human activities like hunting.

Co-extinctions : When a species become extinct the plant and animal species associated with it in an obligatory way also become extinct.

e.g. Plant-pollinator

8. **The characteristics of species particularly susceptible to extinction are :-**
Large body size, small population size, low reproductive rate, feeding at high trophic levels in the food chain, Fixed migratory routes and habitat (e.g : Blue whale and whooping crane) and localized and narrow range of distribution (e.g : Woodland caribou, Island species)

9. **Landscape :** It is a unit of land with a natural boundary having a mosaic of patches. These patches generally represent different ecosystem.
Note : In ecological hierarchy landscape can be present between Ecosystem and Biomes.

10. India is divided into 10 Biogeographical regions.

(i)	Trans - Himalaya	(ii)	Himalaya	(iii)	Desert
(iv)	Semi - Arid	(v)	Western ghats	(vi)	Deccan peninsula
(vii)	Gangetic plain	(viii)	Coasts	(ix)	North east
(x)	Islands				

Note : Deccan peninsula has maximum coverage of the Indian land mass (42%), western ghats 4% and north-east 5.2%.

11. **Endemic Flowering Species of India** – 33% of flowering plants recorded in India, are endemic.

12. **Endemic fauna (Animals Species) of India –** Out of the recorded vertebrates, 60% amphibians, 53% fresh water fish, 36% reptiles and 10% mammalian fauna.

- Maximum endemic amphibian species are found in western ghats.
- From ten high-diversity localities in tropical forest some 17,000 endemic plant species and 350,000 endemic animal species could be lost in near future.
- The tropical forests alone are losing roughly 14,000 - 40,000 species per year (or 2-5 species per hour).
- The earth may lose up to 50 percent of the species by the end of the 21st century.
- According to IUCN (2004), total number of plant and animal species on the earth is 1.5 million.
- According to Robert May global species diversity is about 7 million.
- More than 70 percent of all species recorded are animals, while plants comprise no more than 22%.
- Out of 10 animals on this planet 7 are insects.
- Indians share of the global species diversity is about 8.1 percent.
- Some examples of recent extinction include the dodo (Mauritius), quagga (Africa), thylacine (Australia), stellars' sea cow (Russia) and three subspecies (Bali, Javan, Caspian) of tigers.
- According to IUCN Red list (2004), 784 species were extinct in the last 500 year.
- Last 20 year alone have witnessed the disapperance of 27 species.
- The Amazon rain forest is so huge that is called "Lungs of the Planet".

13. **Wet lands :** Low lying area's covered with shallow water are called wet land's. The wet lands are transitional zones between terrestrial and aquatic area's. **6% of the world's** land surface is occupy by wet lands.

- **Marshes :** Wetlands where grass - like plants dominate.
- **Swamps :** Wetlands where trees or shrubs dominate.

- **Reverine forest :** Periodically Flooded forests found in lowland along streams.
- **Mangrove is salty water swamp**

Significance of Wet lands :

(1) Wetland are higly productive, provide food and habitat.

(2) Wetlands helps to control flooding by holding excess water.

(3) Ground water recharging areas. (4) Help to clean and purify water run-off.

(5) Provides sites for fishing, boating, nature study.

Wetlands conservation measures :

(i) Preparation of wetland inventories.

(ii) Checking waste disposal in wetland.

(iii) Reduction of excessive inflow of nutrients and silt into wetlands.

14. Grassland management measures :

(1) Protection from grazing.

(2) Use of rotational grazing.

(3) Removal of woody bushes or shrubs and weeds.

(4) Conservation of soil and water of grasslands.

(5) Use of controlled burning to promote recycling of nutrients.

Some Other Information related to Grass land –

- India has 16 recognised forest types, which represent a rich diversity.
- In India, the Grass cover area including fallow and waste land is 18% of total land area.
- 37% of land are available for grazing including forest.
- Grassland is also called **rangeland.**
- The conversion of grassland or forest to desert is called desertification.
- The average annual production of dry grass or hay in India is about 250 million tonnes.

15. Conservation and management of water :

Main approaches for conservation of water are :

- Reducing agricultural water wastage by increasing efficiency of irrigation.
- Reducing water wastage in industry by recycling the used water.
- Reducing domestic water wastage by constructing waste water treatment.
- Rainwater harvesting by employing practices to store rainwater and recharge ground water.
- Afforestation and protection of water sheds to improve water economy. Approaches to provide a sustainable supply of high quality water are :

(i) *Construction of dams and reservoirs to ensure year-round supply of water, in addition, controlling flood and generating electrcity.*

(ii) *Desalinisation of seawater and saline ground water and making it fit for drinking and other purposes.*

(iii) *Regular dredging and salinisation of water bodies.*

16. Phenotypic Plasticity

The phenotype is the physical expression of the interaction between genotype of an organism and its environment. The phenotypes show variations due to difference in the environmental conditions with in the local habitat such type of variations are known as phenotypic plasticity.

17. **Ecocline –** Trasition form between two ecotypes called "Ecocline".

18. **Guild –** Organism of same trophic level is known as guild (e.g. Cow, Goat, Rabbit).

19. **Arboreta –** Botanical graden where specific trees & shrubs species are cultivated.

20. **Botanochemicals –** Plants can also be used for the manufacture of innumerable synthetic products called botanochemicals.

21. The key elements that lead to so much variation in the physical and chemical conditions of different habitats are temperature, water , light and soil.

22. Mango trees do not grow in temperate countries like canada and germany, snow leopards are not found in kerala forests and tuna fish are rarely caught beyound tropical latitudes in the ocean due to unfavourable temperature.

23. The salt cancentration (measured as salinity in parts per thousand) is less than 5 percent in inlands water, 30-35 percent the sea and more then 100 percent in same hypersaline lagoons. Some organisms are tolerant of a wide range of salinites (euryhaline) but others are restricted to a narrow range (stenohaline).

24. Diapause : Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause a stage of suspended dovelopment.

25. Predators acting as conduits for energy transfer across trophic levels, predators play other impotant roles. They keep prey populations under control In the absence of predators, prey species could achieve very high population densities and cause ecosystem instability, When certain exotic species are introduced into a geographical area, they become invasive and start spreading fast because the invaded land does not have its natural predators, The prickly pear cactus introduced into Australia in the early 1920's caused havoc by spreading rapidly into millions of hectares of rangeland. Finally, the invasive cactus was brought under control only after a cactus feeding predator (a moth) from its natural habitat was introduced into the country.

    Biological control methods adopted in agricultural pest control are based on the ability of the predator to regulate prey populaion. Predator also help in maintaining species diversity in community, by reducing the intensity of competition among competing prey species. In the rocky intertidal communities of the american Pacific Coast the starfish Pisaster is an important predator. In a field experiment, when all the starfish were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, because of interspecific competition.

    If a predator is too efficient and overexploits its prey, then the prey might become extinct and following it, the predator will also become extinct for lack of food. This is reason why predators in nature are 'prudent'. Prey species have evolved various defenses to lessen the impact of predation. Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator. Some are poisonous and therefore avoided by the predators. The Monarch butterfly is highly distasteful to its predator (bird) because of special chemical present in its body. Interestingly, the butterfly acquires this chemical during its caterpillar stage by feeding on poisonous weed.

    You must have seen the weed Calotropis growing in abandoned fields. The plant produces highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant. A wide variety of chemical substances that we extract from plants on a commercial scale (nicotine, caffeine, quinin, strychnine, opium, etc.,) are produced by them actually as defences against grazers and browsers.

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